Food Research Institute
UNIVERSITY OF WISCONSIN–MADISON

FRI Food Safety Reviews

White Paper: Human Illness Caused by *Campylobacter* spp. from All Food and Non-Food Vectors

M. Ellin Doyle
Food Research Institute,
University of Wisconsin–Madison, Madison, WI 53706

Contents

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

INTRODUCTION

Campylobacter spp. are microaerophilic, Gram-negative bacteria first isolated in the early 1900s from the tissues of aborting sheep and were later detected in some farm animals with diarrhea. Campylobacters are generally more sensitive to environmental conditions than other foodborne bacteria, including *Salmonella*. In the 1970s, they were recognized as a cause of human illness, with *C. jejuni* being the species most frequently described as affecting humans. *C. jejuni* is now one of the most common bacterial causes of human foodborne illness.

Campylobacter spp. usually cause mild to moderate gastrointestinal symptoms in humans. However, some infections involve more severe or prolonged diarrhea and may result in chronic, long-term effects or sequelae, such as reactive arthritis and Guillain-Barré syndrome (a neurological disorder) which can significantly increase disability and treatment costs.

Numerous wild and domestic animals harbor campylobacters, often without exhibiting any symptoms. Natural habitat of these bacteria appears to be the gastrointestinal tract of a wide variety of animals, including livestock, companion animals, and many wild animals such as birds, mammals, and reptiles. Poultry, in particular, are reported to frequently harbor *Campylobacter* spp. With the exception of abortions in sheep and other ruminants and some enteritis in swine and young animals, campylobacters generally do not cause significant illness in animals. However, animal wastes containing *Campylobacter* can contaminate drinking water and plants in the environment, and animals themselves may be a source of infection to humans who handle them.

Foodborne campylobacteriosis is primarily associated with milk and meat, particularly poultry, although there have also been outbreaks associated with fresh produce and seafood. Unlike *Salmonella*, *Campylobacter* does not grow on meat. Some very large outbreaks occurred when drinking water supplies were contaminated. In many countries, the number of cases of foodborne campylobacteriosis now approaches or exceeds the number of cases of salmonellosis.

EPIDEMIOLOGY OF *CAMPYLOBACTER* SPP.

Important Species of *Campylobacter*

Campylobacters isolated from livestock first were assigned to the genus *Vibrio* and then in the 1960s were reclassified as the genus, *Campylobacter* (*27*). In fact, the first reported outbreak believed to be caused by *Campylobacter* occurred in 1938 and was attributed to *Vibrio jejuni* in raw milk (*157*).

C. jejuni is the species most often associated with human gastrointestinal illness. Analyses of >21,000 *C. jejuni* isolates from cases of diarrhea around the world revealed that eight serotypes account for more than 50% of sporadic cases and three strains (HS4 complex, HS2, and HS1/44) appeared to be particularly important (*204*). A virulent, tetracycline-resistant strain of *C. jejuni* (SA) has emerged in ruminants in the U.S. and has been found to match about 9% of the human *C. jejuni* isolates in the CDC PulseNet database. These isolates came from sporadic and outbreak-related cases, with most of the outbreaks attributed to raw milk (*223*).

During the past decade, advances in molecular methods and development of new procedures for culturing fastidious strains of *Campylobacter* have demonstrated that several other species can cause gastrointestinal symptoms or periodontal disease in humans: *C. coli*, *C. fetus*, *C. lari*, *C. concisus*, *C. upsaliensis*, and *C. ureolyticus* (*39, 57, 134, 168, 189, 201*). Multiple species of *Campylobacter* recently were detected in swine cecal contents, with *C. concisus* determined to be the second most common species (*230*). *C. ureolyticus* was detected in humans with diarrhea, in bovine feces, and unpasteurized milk, as well as in dog and cat feces in surveys in Ireland (*144*, *145*). Many *Campylobacter* species are difficult to grow in culture, and laboratories do not always determine the species of *Campylobacter* detected in clinical specimens. So the true distribution and incidence of illness caused by different species is not really known.

Multilocus sequence typing (MLST) uses information on the genetic sequence of seven housekeeping genes in bacterial isolates to assess their similarity to other strains of the same species or genus. A total of 7,992 MLST sequences of 10 *Campylobacter* strains (*jejuni*, *coli*, *upsaliensis*, *concisus/curvus*, *hyointestinalis*, *lanienae*,

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

insulaenigrae, lari, sputorum, helveticus) has been entered into the public MLST website as of November 2014 (*53, 131*). These data are useful in classifying new isolates.

Antibiotic Resistance in Campylobacter spp.

Antibiotic resistance, including multi-drug resistance, is an increasing problem globally. Data from the most recent USDA-NARMS report on antibiotic-resistant bacteria in farm animals indicated about 20–27% of *Campylobacter* isolates from chickens in 2011 were resistant to quinolines and 42–45% were resistant to tetracyclines. About 1.3% of isolates were multidrug-resistant (*186*). Data from Europe reported that the proportions of multidrug-resistant *Campylobacter* in broilers in 2012 were 22.5% (*C. coli*) and 1.6% (*C. jejuni*); for pig isolates, the proportion was 34.6% (*C. coli*) and for cattle, 12.3% (*C. jejuni*). These numbers are averages for European Union countries; in some countries, the percentages are significantly higher than in others (*77*). A recent CDC publication on antibiotic resistance threats in the U.S. listed drug-resistant foodborne bacteria including *Campylobacter* as serious health threats (*206*). Significant levels of antimicrobial resistance have been reported in *Campylobacter* isolates from meat and livestock:

- Retail chicken liver in the U.S. (amoxicillin, oxytetracycline, cephalothin) (*192*)
- Retail chicken and turkey in Canada (ciprofloxacin) (*5, 54*)
- Pigs and chickens with multidrug resistance in Brazil (*29, 60*)
- Broilers, cattle, and pigs in Japan (enrofloxacin) *109*)
- Turkeys with multidrug resistance in Germany (*70*)
- Pigs in China (ciprofloxacin, clindamycin, erythromycin, tetracycline) (*208*)
- Poultry in China resistant to organic arsenic (roxarsone) (*240*)

Numerous other scientific articles demonstrate the global nature of this problem with resistance to antibiotics, some of which are important for treating human infections, reported from many countries in Africa, Asia, Europe, and South America.

Overuse and misuse of antimicrobials in human and veterinary medicine are believed to be the driving force increasing selective pressure for evolution of more drug-resistant strains. Some evidence from recent studies of *Campylobacter* in livestock includes:

- Experiments in Japan demonstrated that 3–4 days after dosing pigs with fluoroquinolones, resistant *Campylobacter* could be detected in animal feces. These bacteria persisted for 21 days after stopping the drug treatment. Other experiments showed that fluoroquinolone-resistant *Campylobacter* could be passed readily from one pig to others when they were housed in one pen (*266*).
- In Canada, treatment of feedlot cattle upon arrival with tetracyclines was found to increase the proportion of tetracycline-resistant *Campylobacter* during the feedlot period (*124*).
- A study of dairy cattle raised on organic and conventional farms in the Midwestern U.S. found antibiotic-resistant *Campylobacter* in animals from both farms. However, a higher proportion of bacteria from the conventional farms exhibited antibiotic resistance (*104*).
- Since 2003, the predominant *C. jejuni* isolate causing abortions in U.S. sheep has been a highly pathogenic, tetracycline-resistant strain called SA (ST-8). Tetracyclines commonly are used in the U.S. to prevent abortions. In contrast, in Great Britain where tetracyclines are not commonly used for this purpose, *C. jejuni* isolates associated with ovine abortions were susceptible to most antibiotics tested (*283*).

Human Illness

Campylobacter spp. are estimated to cause about 845,024 cases of foodborne illness annually in the U.S. (*229*), and FoodNet data from 2013 indicate 13.82 cases of campylobacteriosis occur per 100,000 people. During the past 10 years, incidence has ranged from 12.64 (2008) to 14.28 (2011), without a noticeable, consistent decline. The number of foodborne outbreaks of campylobacteriosis reported to CDC increased from 15 in 2009 to 37 in 2012 (*47*). There is still work to be done to achieve the 2010 National Health Objective of 12.3 and the 2020 objective of 8.5 cases/100,000 (*56*).

Campylobacter spp. ranks either first or second (behind *Salmonella* spp.) in bacterial causes of human gastroenteritis in Europe, Canada, Australia, and New Zealand. (*69, 99, 161, 259*). The European Union reported an overall notification rate of 55.49/100,000 population in 2012. Incidence varies from country to country, in some cases because the

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

effectiveness of national public health surveillance systems vary. Significant increasing trends in campylobacteriosis were observed in 15 countries. Few people died from *Campylobacter* infections, with a calculated case-fatality ratio of 0.03% (*69*). In 2013, Foodnet Canada reported an incidence rate of 29.5 cases/100,000 population (*42*), and Australia reported an incidence rate of 95.3 cases of campylobacteriosis/100,000 population (*114*).

Campylobacter commonly causes mild to moderate symptoms of gastroenteritis and infectious dose appears to be relatively low — about 500 cells or less (*106, 143, 215*). Data from outbreaks in which all cases were exposed to contaminated food or water during a short period of time (<24 hours) indicated 84% of cases experienced symptoms within four days of exposure, and only 1% had an incubation period lasting eight days (*119*). Economic costs for most cases of human campylobacteriosis not involving chronic sequelae usually are relatively low. However, the large number of cases that occur are estimated to cost annually a total of >$1.5 billion in the U.S. (*118, 232*).

Early on, it was noted that some patients recovering from gastrointestinal illness suffered long-term sequelae, such as reactive arthritis (*36, 67*) and Guillain-Barré syndrome (GBS) (*10*). In fact, sometimes a cluster of cases of GBS indicates a recent outbreak of campylobacteriosis. This was the case in 2011 when a binational outbreak of GBS in Arizona and Mexico was found to be associated with a large outbreak of *C. jejuni* caused by inadequately disinfected water in Mexico (*126*). It appears persons suffering more severe or prolonged gastrointestinal symptoms are more likely to develop GBS or reactive arthritis (*163, 234*).

GBS is an acute neurological disorder that first affects peripheral nerves, causing numbness and tingling in hands and feet and weakness in muscles of the arms and legs. Most people recover after several months. But in some cases, the disease progresses to affect muscles controlling breathing and heart rate and may have serious consequences. *Campylobacter* infections are one of the primary triggers causing this disease because some lipo-oligosaccharide structures on the bacterial cell surface are very similar to ganglioside molecules on nerve surfaces. Therefore, in attempting to fight off the *Campylobacter* infection, the body produces antibodies that also attack its own nerves. More recent studies of GBS cases in several countries have utilized molecular and serological methods involving isolation and testing of antibodies from GBS patients for cross-reactivity with *Campylobacter* to demonstrate the connection between this foodborne infection and neurological disease. One study indicated that 34–49% of GBS cases had evidence of previous *Campylobacter* infection (*125, 289, 292*).

Reactive arthritis is another long-term effect of some food poisoning episodes (*7, 261*). It has been reported that the incidence of reactive arthritis following *Campylobacter* and *Salmonella* infections were 2.1 and 1.4/100,000, respectively (*262*). One study found that 44–62% of cases of reactive arthritis had serological evidence of a previous *Campylobacter* infection (*289*). Following a large waterborne outbreak of *Campylobacter*iosis in Finland in 2007, 7% of the exposed population reported newly developed arthritis-like symptoms. These symptoms persisted longer than gastroenteritis and some persons reported continuing joint pain 15 months later (*151*).

Normal gut flora in individuals appears to affect susceptibility to *Campylobacter* infection. Poultry abattoir workers with a significantly higher abundance of *Bacteroides* in their gut microbiota were more likely to become culture positive when exposed to *Campylobacter* than those with lower proportions of *Bacteroides*. In addition, infection/colonization of workers with *Campylobacter* significantly altered the composition of their intestinal microbiota (*63*). Such alterations in microbiota may, in turn, be a possible mechanism for development of chronic gastrointestinal symptoms (*251*). Campylobacters are suspected of playing a role in the development of some chronic gastrointestinal conditions. There are indications that more severe gastrointestinal symptoms during campylobacteriosis may be a factor in development of inflammatory bowel disease (*289*), irritable bowel syndrome (*190*), and celiac disease (*214*) in some individuals.

Outbreaks and Cases

Data on outbreaks tabulated by CDC (1998–2012) indicate dairy products were responsible for about 50% of outbreaks with a known or suspected vehicle, and poultry was responsible for another 19% (*47*). Raw milk continues to be a source of infection in the U.S. (*183*) and the most recent outbreak in 2014 in Wisconsin affected 38 people who consumed raw milk served at a dinner for a high school football team (*24*). Another recently recognized vehicle is liver pâté, which has caused numerous small outbreaks in the UK and other countries in recent years. Since liver becomes tough when overcooked, some chefs only lightly cook liver, thereby permitting the survival of *Campylobacter* (*81*). Although *Campylobacter* spp. are sensitive to stomach acid, the presence of food and liquids in the diet may offer some protection until the bacteria reach the relative safety of the small intestine.

Table 1 lists some of the large foodborne *Campylobacter* outbreaks reported in the past 15 years, and Table 2 lists some large drinking water outbreaks. Overall, waterborne outbreaks account for about 17% of reported outbreaks with a known cause. However, in terms of cases, contaminated water caused nearly 75% of cases because many waterborne outbreaks involve hundreds or thousands of cases (Figure 1). A total of 504 outbreaks affecting 57,221 people was described in the scientific literature and was compiled in the Appendix to this paper.

For strictly foodborne outbreaks and cases, milk accounts for a very large percentage of outbreaks and cases. Meat also accounts for about a third of outbreaks and 18 % of cases (Figure 2). Chicken is associated with a majority of meat-related outbreaks and cases. From data gathered for this paper, pork appears to be a major cause of campylobacteriosis, but this is due to one large Japanese outbreak affecting about 800 people (Figure 3). Relatively few outbreaks are caused by fresh produce, fish, animal contact, and person-to-person transfer, although all of these types of outbreaks have occurred.

As with other foodborne pathogens, epidemiologists estimate many more sporadic cases than reported outbreak cases of campylobacteriosis occur (*217*). A multiplier of 30.3 has been used to account for underdiagnosis in order to estimate the actual number of cases of campylobacteriosis in the U.S. (*229*). It is unclear whether the same vehicles of infection are causing sporadic cases in approximately the same proportions. Studies in different countries have implicated several vehicles, but results of these studies are not necessarily comparable because different questions were asked and different definitions used (*86*). Campylobacteriosis risk factors undoubtedly vary somewhat by age because of differences in occupational and leisure time activities and consumption of different foods (*46*, *62*). Risks likely also vary somewhat geographically. Among the risk factors identified as associated with sporadic campylobacteriosis are drinking well water or surface waters as compared to ground water (*46*, *195*, *264*), consumption of chicken or other meat (*46*, *80*, *88*, *187*, *265*), consumption of restaurant food (*62*, *88*, *265*), and poor kitchen hygiene probably resulting in cross-contamination (*62*, *88*).

Reservoirs of Campylobacter

Livestock

Cattle. *Campylobacter* commonly is detected in fecal material from cattle. Analysis in 2013 by the Public Health Agency of Canada of manure samples from broilers and cattle revealed *Campylobacter* was present in about 75% of dairy and beef cattle manure (*42*). Some recent surveys reported incidences of *Campylobacter* in fecal samples of about 50% of dairy cattle in Finland (*103*), 42% of dairy cows in Japan (*228*), 28% of dairy cattle in Canada (*101*), 15% of calves in Austria (*142*), and 19% of cattle in South Africa (*263*). Several studies examining factors related to *Campylobacter* among dairy cattle reported inadequate biosecurity measures, indoor housing (such as in winter), larger herd size, and infrequent cleaning of water troughs were associated with a higher incidence of *Campylobacter* (*71*, *101*, *142*, *210*). Some bacterial strains persist for a long time in cattle herds and appear to be adapted for life in cattle (*149*).

Small ruminants. Both sheep and goats may harbor *Campylobacter*, but goats appear to be colonized less frequently (*155*, *198*). However, in some locations, *Campylobacter* may be present in a significant number of goats and in goat meat (*181*). *Campylobacter* strains detected in grazing small ruminants in the U.S. differed from those detected in wild birds in the same environment (*198*).

Campylobacter, particularly *C. fetus*, is a well-known cause of abortions in sheep. Vaccination of sheep with antigens from *C. fetus* does protect pregnant sheep from this species (*169*). *Campylobacter* spp. can be present in sheep fecal samples and may also be isolated from gall bladders of adult sheep (*75*).

Poultry. *Campylobacter* generally is considered a commensal organism in poultry, i. e. it exerts no harmful effects on the birds. However, some recent research indicates various breeds of chickens react differently to *Campylobacter* colonization, and in some breeds, there is a long inflammatory response, damage to the gut lining, and diarrhea (*122*).

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu

Funded in part by the North American Meat Institute

Reports of the prevalence of *Campylobacter* in poultry vary by country because of different surveillance procedures and husbandry practices as well as geographical and climatic differences. Generally, *Campylobacter* isolations peak in summer and fall and decline during winter (*50, 109, 277*). A wide range in the incidence of *Campylobacter* in broilers was reported from European countries from 1.6% of animals tested (Finland) to 83.6% of animals (Hungary). While results are not strictly comparable between countries because of differences in sampling programs, the four countries with *Campylobacter* control and surveillance programs reported low to moderate levels of *Campylobacter* (1.6–11.6%) (*68*).

According to the USDA quarterly report (Jan–Mar 2014) on *Campylobacter* in poultry, 1.6% of 367 turkeys and 5.9% of 1,415 young chickens harbored *Campylobacter* (*238*). Manure samples from broilers and turkeys collected in 2013 by the Public Health Agency of Canada revealed *Campylobacter* was present in 20–28% of broiler manure and about 80% of turkey manure (*42*). Surveys conducted at poultry slaughterhouses in Canada found *Campylobacter* in 35.8% of chickens (*16*) and 36.9% of turkeys (*17*). Reports from other countries indicate *Campylobacter* was detected in:

- 35% of chickens on farms in South Africa (*263*),
- 42.7% of flocks tested in Japan (*109*)
- 60% of breeding hens in Argentina (*290*)
- 76.1% of broiler flocks, 90% of turkey flocks, 68.2% of Muscovy duck flocks, and 59% of Pekin duck flocks kept on the same farms in Germany (*277*)
- 75.6% of chickens at wet markets in Malaysia (*170*)
- 38% of chickens and 62.9% of poultry flocks in Spain (*260*)

Origins of infection in poultry have been investigated by several researchers. Chicks start shedding *Campylobacter* in feces at around four weeks of age, although they may harbor these bacteria in their ceca before they start shedding (*94, 285*). *Campylobacter* on particles of dust, food, or feces may be ingested by poultry. *Campylobacter* concentrations in feces of colonized birds may be as high as 10^8 cfu/g and may remain viable for 5–6 days after deposition (*6*). Drinking water that has not been disinfected was identified as a likely source of infection for chicks (*109, 260*). Other animals on a farm may also be a source, or, in the case of rodents for example, may spread *Campylobacter* around the farm environment (*260*). A study in Switzerland found similar *Campylobacter* strains were present in poultry, pigs, and cattle living on the same farm. Some strains were observed first in poultry and then in other livestock, while other strains were isolated first from other livestock (*294*). Thinning of flocks also appears to increase *Campylobacter* colonization in flocks (*94, 260*).

Although multiple *Campylobacter* strains often are detected in poultry (*105, 242*), it appears certain strains may be better adapted for survival in chicken gastrointestinal tracts (*18*).

Swine. Pigs commonly harbor *Campylobacter* spp., usually *C. coli*, often without becoming ill. However, *C. coli* and *C. jejuni* have been the only pathogens detected in some swine with diarrhea (*41*). Piglets may be colonized during the first week of life, often from contact with their mothers, and prevalence of *Campylobacter* usually increases during life so that at the finishing stage, the majority of pigs harbor *Campylobacter*. At slaughter, a large percentage of pigs carry *C. coli* in their digestive tracts and, to a lesser extent, in their tonsils (*21*). A recent examination of fastidious campylobacters in swine cecal contents found a wide range of species and found that *C. concisus* was the second most common species (*230*). When chlortetracycline was fed to pigs, it was reported to decrease numbers of *Campylobacter*, but not pathogenic *E. coli* in fecal samples (*280*).

Other farmed animals. *Campylobacter* spp. occasionally have been reported from other animals raised on farms.

- Rabbits in Italy and Portugal were reported to commonly harbor a new thermophilic *Campylobacter*, *C. cuniculorum*. *C. jejuni* and *C. coli* were detected in only a few animals (*212*).
- *Campylobacter* spp. were detected on about 10% of ostrich carcasses sampled at slaughterhouses in Ohio and Indiana (*159*).
- *Campylobacter* spp. were detected in 80% of ducks sampled in Tanzania (*191*) and in 12% of ducks tested in Malaysia (*79*).
- Assays of 500 fecal samples from farmed camels in Saudi Arabia revealed the presence of *Campylobacter* spp. in about 5% of them. Most were identified as *C. jejuni*, with a few isolates of *C. coli* and *C. lari* (*9*).
- *Campylobacter* has been reported to cause abortions in farmed alpacas in England (*30*) and in mink on Canadian ranches (*123*).

Companion Animals

Dogs. Of all companion animals, dogs appear to be the most important reservoir for *Campylobacter* spp. Research has demonstrated that the same or very similar strains of *Campylobacter* are present in dogs and humans (*182, 253*). Ownership of dogs is one of several risk factors for *Campylobacter* infection in humans (*246*), and one study attributed about 8.6% of sporadic human campylobacteriosis to contact with dogs (*138*). A human outbreak of *Campylobacter* enteritis was associated with dogs (*137*).

Surveys in Australia, Canada, Chile, India, Iran, Ireland, Slovakia, and Spain reported 30–50% of healthy dogs carried *Campylobacter* and excreted the bacterial cells in their feces (*1, 20, 23, 44, 48, 82, 207, 269*). Prevalence of *Campylobacter* in healthy Swiss dogs was reported to be only 6.3% (*11*). The most common species identified in these surveys were *C. upsaliensis* and *C. jejuni*, with smaller numbers of *C. coli*.

Campylobacter shedding is more frequent in summer and is more common in puppies and old dogs, in dogs at shelters, and in dogs with access to ponds and lakes (*1, 23, 44, 82, 207*). Some *Campylobacter* strains appear to cause diarrhea in dogs (*11*).

Cats and other mammals. Healthy cats in Minnesota were found to harbor *C. upsaliensis*, *C. jejuni*, and *C. coli* with an overall *Campylobacter* prevalence of 24%. As with dogs, *Campylobacter* was more frequently isolated from young cats, less than one year old (*28*). *C. ureolyticus*, an important cause of human gastroenteritis, has been detected in 32% of cat fecal samples in Ireland, as well as in dog feces (*144*). Surveys of cats in The Netherlands (*182*), Norway (*224*), Iran (*48*), and Poland (*13*) also reported these animals carry *Campylobacter* spp. The Polish cats had been in contact with poultry or wild birds.

Campylobacter occasionally has been isolated from horses (*294*). *Campylobacter* spp. and *E. coli* were identified as probable causes of diarrhea and enterocolitis in a hamster colony, suggesting small mammal pets may also be a source of human infection (*64*).

Birds. A study of "hobby" birds in Denmark in 2000–2001 detected *Campylobacter* in 4% of parrots and canaries, 11% of racing pigeons, and 77% of hens and peacocks (*278*). A recent review of zoonoses associated with pet birds (*33*) indicated *Campylobacter* can be shed by asymptomatic canaries, parakeets, and parrots. However, the strains isolated from these birds appear to be host specific and may not pose a risk to human health.

Reptiles. Although few surveys of *Campylobacter* in reptiles have been published, it appears this group of animals is not a major reservoir of *Campylobacter*. Only 6.7% of human-raised reptiles (turtles, lizards, snakes) in Taiwan tested positive for *Campylobacter*, and all isolates were identified as *C. fetus* strains that differed from most mammalian *C. fetus* strains (*276*). Only eight of 109 captive reptiles in Italy tested positive for *C. fetus* or *C. hyointestinalis* (*92*). These species rarely are detected in humans and may not pose a risk to pet owners. No *Campylobacter* spp. were detected in 200 pond turtles in Spain, although many turtles did harbor *Salmonella* (*171*).

Wild Animals

Campylobacter spp. also are present in many wild animals, although their public health significance is unclear. Rodents, insects, and birds may disperse *Campylobacter* in the environment, and colonized game animals may pose some risk to hunters. Wild non-human may also may harbor *Campylobacter* and may pose a risk to hunters and to researchers who work with these animals (*188, 202*).

Surveys have demonstrated the presence of *Campylobacter* in rodents on farms (*2, 19*) and those living in human facilities (*164*). Squirrels also have tested positive for these bacteria (*65*). Among larger game animals, *Campylobacter* is detected more frequently in wild boar/feral swine than in deer (*43, 127, 225*).

Birds have played a role in some outbreaks of human *Campylobacter*iosis. In the late 1980s in England, jackdaws and magpies pecked at the tops of milk bottles left outside houses and introduced *Campylobacter* into the pasteurized milk, causing human illness (*121*). An outbreak of campylobacteriosis in Alaska in 2008 was traced to consumption of raw peas apparently contaminated by sandhill cranes that frequented the farm fields. *C. jejuni* was detected in crane feces (*148*). However, it appears many *Campylobacter* strains carried by birds are distinct from those present in other species (*97*). An infection experiment demonstrated European robins could be colonized by *Campylobacter* isolates from related birds, but not by *Campylobacter* isolates from humans (*275*).

Numerous surveys reported detection of *Campylobacter* spp. in birds, including:

- 9.2% of wild ducks and gulls in mid-Atlantic U.S. (*136*)
- 5–16% of urban geese in North Carolina (*220*)
- 7% of wild raptors in Spain (*178*)
- Penguins in Antarctica (*98*)
- 67% of crows in California (*279*)

Numerous insects live on farms and may contribute to the spread of pathogenic organisms to various environmental surfaces and among the many animals living there. *Campylobacter* has been isolated from flies on dairy farms (*2*), poultry farms (*49*), and pig farms (*185*). Contaminated insects also may be eaten by livestock. Broilers fed darkling beetles contaminated with *Campylobacter* were colonized with the bacteria (*113*).

Routes or Vehicles of Human Infection

Contaminated Food and Water

Food containing *Campylobacter* spp. is one of the main sources of human campylobacteriosis. Such food may be consumed directly, either raw or lightly cooked, and may cross-contaminate other foods, such as salad ingredients, during food preparation.

Campylobacter also was present on the external packaging of retail raw meat during a study in the UK. Contamination was observed less frequently when packaging was intact, display areas were visually clean, and display temperatures were <8ºC (*40*).

Dairy products. Milk, particularly raw milk, is the most common cause of campylobacteriosis outbreaks (Figure 1). More outbreaks associated with raw milk have occurred in the U.S. from 2007 to 2012 (*183*). Milk may be contaminated by fecal material on the udder or lapses in hygiene control during milking. Direct excretion of *Campylobacter* into milk by cows also has been documented (*197*)

Several studies have documented the presence of *Campylobacter* in raw bulk-tank milk. Reported prevalence varies, including:

- 0% of tanks from 183 Finnish farms and 310 from Swiss farms, although some samples contained *L. monocytogenes* or *E. coli* O157:H7 (*221*, *248*).
- 9.2% of 131 tanks from Minnesota and South Dakota (*129*)
- 2% of tanks in Pennsylvania (*128*)

Campylobacter spp. was detected in 16 of 49 inline milk filters from 14 farms in Italy authorized to sell raw milk. *Arcobacter* spp. was detected in 36 filters (*237*).

Monitoring of more than 60,000 containers of raw milk sold in vending machines in Italy from 2008–2011 revealed the presence of bacterial pathogens (*Listeria monocytogenes*, *Salmonella*, *Campylobacter*, and *E. coli* O157:H7) in 0.3% of raw milk samples. *Campylobacter* spp.was detected in 30% of the positive samples (*93*).

Of reported sporadic enteric infections occurring in people who consumed raw milk in Minnesota from 2001–2010, 77% (407 cases) were caused by *Campylobacter*. Using a multiplier to account for underdiagnosis, the actual number of cases was estimated to exceed 12,000. In contrast, only 15 outbreak-related cases of campylobacteriosis were associated with raw milk during this period. Even if some sporadic cases were not caused by raw milk exposure, these data indicate the number of sporadic cases due to *Campylobacter* in raw milk greatly surpasses the number of outbreak cases (*217*).

Fermented dairy products and butter are not as good media for survival of *Campylobacter* because of organic acids in the former and lack of water in the latter. However, an outbreak in 1995 was attributed to *C. jejuni* in garlic butter and subsequent investigations found that *C. jejuni* could survive in plain butter for fewer than three days at 21ºC and for at least 13 days at 5ºC. These bacteria died within several hours at both temperatures if garlic was present (*293*). Traditional cheeses and butter as well as raw milk in Iran were found to be contaminated with *Campylobacter* (*209*).

Chicken. Poultry commonly is contaminated with *Campylobacter* and often is implicated as a vehicle for human campylobacteriosis. In the previous section on animal reservoirs of *Campylobacter*, data were presented on the presence of *Campylobacter* in live animals and in animals just after slaughter. This section considers contamination of poultry meat during processing of animals in slaughterhouses and in meat sold in retail establishments.

USDA quarterly report (Jan–Mar 2014) on *Campylobacter* in poultry found that 0.88% of turkey meat and 10.77% of chicken meat were contaminated with *Campylobacter*. Mechanically separated chicken and turkey were 5–10 times more contaminated than ground or other comminuted meat (*238*). Analyses in 2013 by the Public Health Agency of Canada of retail chicken breasts and ground chicken detected *Campylobacter* in 44–46% and 17%, respectively (*42*). Data from the second quarter of a year long (2014–2015) survey of *Campylobacter* in retail whole chickens in the UK indicated 70% of birds were contaminated, with 18% containing >1000 cfu *Campylobacter*/g. In addition, *Campylobacter* was detected on the outside of 6% of packages of chicken (*3*).

Wide variations in contamination of chicken meat with *Campylobacter* have been reported from surveys in different countries. This most likely is due to differences in types of meat sampled (e.g. whole chickens, giblets, breast muscle, meat with skin, meat without skin), in sampling and culture methods, and in seasons when samples were collected. Some percentages of positive results from surveys published in the past five years are listed below:

- 67% of retail livers and gizzards in the U.S. (*192*)
- 90% of whole chickens from farmers' markets in Pennsylvania; 28% of whole organic chickens and 52% of whole conventional chickens from supermarkets (*233*)
- 42.8% of retail poultry in Canada (*45*)
- 81% of retail poultry liver in the UK (*249*)
- 38.4% of retail chicken in Switzerland (*25*)
- 54.2% of organic and 19.7% of non-organic chicken carcasses at the end of processing and chilling in Denmark (*219*)
- 20.8% of retail chicken in Estonia (*167*)
- 49.7% of chicken, turkey, quail, and partridge meat in Iran (*291*)

Fate of *Campylobacter* present in live poultry has been traced through the slaughtering process. Identical *Campylobacter* clones were detected in chickens at farms, on carcasses during individual steps during processing, and in final packaged cuts of meat ready for retail sale (*160, 175*). For flocks known to carry *Campylobacter*, some reductions in numbers of bacteria were seen after certain points in the processing line, but significant numbers still were present at the end of processing. Even carcasses from flocks that had tested negative for *Campylobacter* contained *Campylobacter* by the end of processing, indicating the abattoir environment itself harbors *Campylobacter* that can contaminate carcasses during processing (*74*). *Campylobacter*-negative flocks processed at a slaughterhouse after a *Campylobacter*-positive flock can acquire the same bacteria strains as were present in the positive flock (*226*).

Campylobacter on raw poultry may pose a direct risk to human health if the chicken is not cooked properly. It may also serve as a source for cross-contaminating other foods and equipment in the kitchen. In nearly 30% of trials, *Campylobacter* from raw chicken was transferred to a polyethylene cutting board and then to cooked chicken placed on the contaminated board (*102*). In another study, transfer rates of *Campylobacter* on raw chicken to hands and kitchen equipment were measured. Rates of transfer from chicken legs and filets to hands were 2.9% and 3.8%, respectively. Transfer from filets to wooden cutting board and knife was about 1.1% and from legs to plate was 0.3%. Transfer from the plate to fried sausage was 27.5% and from knife and cutting board to raw cucumber was 10% (*166*). This research quantifies the significant risk for cross-contamination from raw chicken during food preparation.

According to a recent review, data from published studies on the potential for biofilm formation by *C. jejuni* indicate this bacterium is not very proficient at forming biofilms by itself. Rather, it may persist in food-related environments by attaching to biofilms formed by other bacteria (*255*). However, chicken meat exudate was found to enhance attachment and biofilm formation by *C. jejuni* on glass, stainless steel, and polystyrene. It appears particles in this chicken juice attach to abiotic surfaces, which may allow attachment and increase survival of *C. jejuni* in kitchens and processing plants (*37*). Rinsate of broiler carcasses, containing 10^4–10^5 cfu *Campylobacter*/ml was stored for up to 24 months at refrigeration or freezer temperatures. *Campylobacter* could be cultured after enrichment for up to four months from samples stored at 4ºC and for up to 20 months in samples stored at -23ºC. It appears that, although most of the bacteria were killed during cold storage, sublethally injured bacteria could be resuscitated after 4–20 months (*55*).

Turkey. A survey of 465 packages of retail raw turkey in Canada revealed 46% contained *Campylobacter* (*54*).

Beef. Analyses of 1,185 samples of beef purchased in retail stores in 38 cities in the U.S. detected *Campylobacter* in 7.35% of ground beef packages and in 17.24% of whole muscle beef. This was significantly higher than *Salmonella* incidence (1% or less) in the same packages of meat (*271*).

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

Another survey of retail beef in the Tulsa, Okla. area found 78% of beef liver samples contained *Campylobacter*, while none of 47 packages of other beef cuts were contaminated (*193*). In the UK, 69% of retail bovine liver contained *Campylobacter* (*249*). No *Campylobacter* could be cultured from 175 samples of ground beef from Finland, although one sample tested positive by PCR (*162*).

Pork. A survey of retail pork in the Tulsa, Okla. area found 2% of 100 samples contained *Campylobacter* (*193*). Swine livers collected at slaughter were reported to be contaminated with *Campylobacter* at a rate of 17.3% in Japan (*227*) and 10% in Germany (*273*). In the UK, 79% of retail pig livers were contaminated with *Campylobacter* (*249*). *C. coli* on raw porcine liver slices was found to survive up to four days at 4–37ºC, but no growth occurred at any temperature (*180*). Another survey found 15% of retail pork products in Ireland contained *Campylobacter* (*230*).

Mutton, Lamb. *Campylobacter* commonly is not present on lamb or mutton muscle. It was detected on only 0.3% of lamb carcasses in the U.S. (*66*) and on 3% of sheep carcasses in Italy (*31*). A survey in Australia detected *Campylobacter* on only one sample of lamb and sheep legs (*203*). However, a survey in Greece found *Campylobacter* on 44% of liver and 32% of meat samples from lambs and goat kids (*154*). In the UK, 78% of retail sheep livers were contaminated with *Campylobacter* (*249*).

Produce. *Campylobacter* spp. is present on fresh produce from the field, but prevalence appears to be quite variable. Examination of fresh vegetables at Canadian farmers' markets found that six types of vegetables, including leafy greens, radishes, and potatoes, were contaminated with *Campylobacter* spp. *C. jejuni* was the most commonly detected species (*199*). In more than 1,800 samples of fresh retail produce tested in The Netherlands, only three (lettuce, endive) were contaminated with *Campylobacter* (*281*). *Campylobacter* was detected on raw parsley, but not on many other retail produce items during a survey in Mexico (*95*).

Survival of *Campylobacter* on fresh produce varies with type of produce and whether the plant part is above or below ground. *Campylobacter* survived significantly longer on strawberries than on carrots, cucumber, and cantaloupe (*135*). *C. jejuni* could survive and be cultured for at least 23 days after inoculation on radish and spinach roots kept at 10ºC but declined more rapidly on spinach leaves, lasting for only six days. Higher temperatures decreased longevity, while leaf damage increased survival (*34*).

Fresh produce also can be cross-contaminated in restaurant or home kitchens where meat also is being prepared. Recurring cross-contamination of salads occurred in an Austrian kebab shop and was attributed to poor kitchen hygiene (*172*). Risk assessment for human campylobacteriosis from salad vegetables prepared in a kitchen alongside broiler meat was associated with frequency of washing hands and cutting boards and the preparation of raw poultry before salads using the same cutting board (*241*).

Seafood. In contrast to pork and chicken, some seafood traditionally is consumed raw. Several outbreaks have been traced to consumption of raw clams, oysters, salmon, and tuna (*47*). Shellfish are filter feeders and may accumulate bacteria from surrounding sea water. Since they often live near shore, they may be exposed to runoff of animal and human wastes.

Eggs. Although chickens commonly harbor *Campylobacter*, eggs are not a common vehicle for campylobacteriosis, having been implicated only in a single 1982 outbreak in Minnesota. When commercial eggs were surface contaminated with a fecal suspension containing *C. jejuni*, the bacteria were detected inside of only one of 70 eggs. *Campylobacter* remained viable on the shell surface for a maximum of 16 hours. Furthermore, hens known to shed *C. jejuni* did not produce contaminated eggs (*239*).

Water. Several large outbreaks of campylobacteriosis have been traced to contamination of public drinking water. Causes have been identified as cracks in aging pipes and water storage facilities, cross-connections between drinking water pipes and sewage or non-potable water pipes, contamination of wells or reservoirs by surface runoff following heavy rains or rapid snow melt, or failure of water treatment, usually chlorination (see Table 2 for examples). Waterborne disease outbreaks occurring in developed countries during the past 30 years were reviewed to determine why these outbreaks keep occurring even when we know how to prevent them (*120*). An epidemiological study of sporadic campylobacteriosis in British Columbia reported use of private well water rather than municipal drinking water was associated with increased risk (*87*).

Some smaller waterborne outbreaks of campylobacteriosis have been associated with recreational exposure to water in lakes or swimming pools (*107, 156, 287*). One outbreak was caused by contaminated bagged ice (*158*).

Other Routes of Infection

Since *Campylobacter* may be excreted in animal feces at concentrations as high as 10^8 cfu/g, it is reasonable to expect hides and feathers of farm animals may be contaminated. Several outbreaks were traced to lambs, calves, chickens, and pigs encountered by children during visits to farms and petting zoos (*179, 244, 247*). In addition, farm workers may contract campylobacteriosis from livestock, including turkeys (*72*) and sheep (*267*). Abattoir workers also have occupational exposure to *Campylobacter* and may be colonized while handling chickens (*73*).

Person-to-person spread of *Campylobacter* spp. is not observed frequently but has been documented in intensive care wards in hospitals (*115*), in a day care center (*96*), and through sexual contact in homosexual men (*91*).

An unusual vehicle for campylobacteriosis was reported to be ingestion of mud by 225 symptomatic racers during a mountain bike race in Canada in 2007 (*250*).

INTERVENTIONS

Epidemiological evidence indicates a large proportion of human cases of campylobacteriosis result from contaminated poultry, particularly by cross-contamination in food preparation areas from raw chicken to other foods that will be consumed without further cooking. Consequently, there has been a great deal of thought and discussion on effective strategies for reducing exposure of live poultry flocks to *Campylobacter* and for minimizing contamination of poultry carcasses with pathogens living in the ceca during processing at abattoirs. It likely is impossible to ensure the absence of *Campylobacter* on all chicken, but this should be acceptable. Unlike other pathogens, such as *Listeria* and *Salmonella*, *Campylobacter* cannot increase on meat, so a small number of these bacteria on carcasses will not reach dangerous levels during chilled storage or even moderate temperature abuse. However, food handlers and consumers should understand the potential for cross-contamination in the kitchen and how to prevent it.

European Food Safety Authority (EFSA) proposed and summarized evidence for several *Campylobacter* control strategies along the poultry production and processing chain (*76*). Strict implementation of biosecurity measures at farms may reduce colonization of chickens and other practices, such as the use of fly screens, and some changes in husbandry practices may further decrease the number of *Campylobacter*-positive flocks. GMP/HACCP plans, including hot water and chemical carcass decontamination, may reduce bacterial numbers on carcasses during slaughter. Freezing carcasses for 2–3 weeks can reduce human health risk from contaminated meat by as much as 90%. A reduction of >50% in public health risk from *Campylobacter* could be achieved if all batches of poultry complied with a critical limit of 1,000 cfu *Campylobacter*/gram of neck skin. Food Standards Agency of the UK recently updated its strategy to better control campylobacteriosis (*84*). WHO also published a recent report discussing the worldwide problem of campylobacteriosis and poultry production systems in different countries necessitating different strategies for control of this pathogen (*282*).

New Zealand experienced an increasing rate of campylobacteriosis, starting in the 1980s and peaking in 2006. A range of voluntary and regulatory interventions targeting the poultry industry and consumer behavior wsd undertaken near this time, resulting in a significant drop in incidence of campylobacteriosis. A study of the cost effectiveness of these interventions found the health benefits exceeded the costs of preventive measures (*152, 236*).

Preharvest Control

Biosecurity measures to prevent importation of *Campylobacter* or *Campylobacter*-positive animals into a farm are a first line of defense. In addition, good hygiene measures and husbandry practices can prevent or decrease colonization of animals. But these strategies are not completely effective, and other measures have been investigated.

- Drinking water is suspected to be a means of spreading *Campylobacter* through chicken flocks (*245*). This cycle may be interrupted by thorough cleaning of the water distribution system in broiler houses. Adding bactericidal agents, such as electrolyzed oxidizing water (*38*) and organic acids (*111*), also can decrease contamination of water with *Campylobacter*.

- Administration of bacteriophages that lyse *Campylobacter* to chickens in an attempt to reduce pathogen loads has been reviewed recently. Many phage preparations have been shown to significantly reduce *Campylobacter* levels within a few days. However, the effectiveness of this technique depends on the susceptibility of the resident population (not all *Campylobacter* strains can be infected by a particular phage) (*139*). Furthermore, when susceptible *Campylobacter* die off, they may be replaced by more resistant *Campylobacter* strains, which may not reduce overall numbers of pathogens (*83*). Adding bacteriophages to poultry drinking water a few days before slaughter might be effective in reducing contamination of birds during processing (*140*).
- Oral administration of antibodies raised against flagellar proteins (*213*) or colonization associated proteins (*8*) of *Campylobacter* to chicks reduced colonization of the ceca by *C. jejuni*.
- Several attempts to produce commercially useful vaccines to prevent *Campylobacter* colonization of chickens have had little success (*14, 286*).
- Probiotic cultures fed to chickens have reduced carriage of salmonellae and ongoing research is testing whether this strategy will reduce colonization by *Campylobacter.* Although some early studies suggested this approach might work (*235*), other more recent in vivo trials have produced mixed results, and significant inhibition of *Campylobacter* has not been observed in large trials under farm conditions (*4, 218*).
- Effect of the adding several organic compounds and phytochemicals to poultry feed on *Campylobacter* levels in chickens has been reviewed (*268*). One potential problem with using phenolic compounds as *Campylobacte*r inhibitors is that some bacterial drug efflux systems actively can expel these compounds from *Campylobacter* cells (*141*).
- Flies are potential transport hosts for *Campylobacter* and some other zoonotic pathogens. Fly screens installed on commercial broiler houses in Denmark reduced the prevalence of *Campylobacter* positive flocks from 41.4% to 10.3% (*22*).
- Tests with pigs found *Campylobacter* levels in cecae could be reduced by including lupine in feed for one week before slaughter (*130*) and in feces of piglets by adding high levels of zinc oxide (3.1 g ZnO/kg feed) to feed (*35*).
- Other feed additives also have been tested for controlling *Campylobacter* colonization of swine. Results have been mixed, and some interventions decrease feed efficiency in the animals (*21*).

Slaughterhouse Hygiene

In a study in The Netherlands, scientists estimated establishment of a critical limit of 1,000 cfu *Campylobacter*/g raw chicken could reduce the number of human illnesses by about two-thirds. Surveys of chicken processed at slaughterhouses showed that about one-third of the batches exceeded this critical limit. Performance by individual slaughterhouses varied: In the poorest performing slaughterhouses, 57–65% of batches exceeded the limit, while in the best slaughterhouses, only 4–11% of batches exceeded the limit. Improving performance likely would entail some increased costs for processors, but the estimated savings in economic costs caused by illness in the general population was estimated to be about four times greater (*252*).

Strategies to determine food safety performance objectives for *Campylobacter* on broiler carcasses after chilling were discussed using quantitative methods to determine an objective for a maximum concentration of this bacterium that would accomplish an appropriate level of protection (established by regulatory authorities). The EU is considering establishing such microbiological criteria for *Campylobacter* (*58*).

Chilling of carcasses is an important step in processing. Of three chilling methods tested (immersion chill, air chill, and a combination in line air chill), the immersion chill was most effective and reduced *Campylobacter* levels by 43%. This was likely due to the presence of chlorine as well as the washing effect. (*61*) Several methods for cleaning poultry carcasses have been described.

- A combination of steam and ultrasound significantly reduced *Campylobacter* levels on poultry carcasses in Danish slaughterhouses (*184*)
- Use of electrolyzed oxidizing water and lactic acid in rinsing tanks resulted in small decreases of 1 to 1.5 log of *Campylobacter* on chicken carcasses (*211*)

Control Strategies for Meat and Other Foods

Meats usually are cooked and milk usually pasteurized before consumption, and these thermal processes should kill any *Campylobacter* cells present. D values for *C. jejuni*/*coli* at 55, 60, 65, and 72ºC have been reported as 50, 8.2, 1.3, and 0.1 seconds, respectively (*243*). D values were determined for other species of *Campylobacter* using an immersed coil apparatus and nine models were assessed to determine thermal inactivation (*231*). However, D values commonly are determined when cells suspended in laboratory media and factors associated with real foods are known to be protective. Some experiments measuring D values for *Campylobacter* on chicken breasts during boiling demonstrated the actual decimal reduction time during normal cooking can be as long as 1.9 minutes. A surface probe indicated the temperature at the chicken's surface reached 85ºC within a minute. In these trials, the chicken was inoculated with *Campylobacter* and then refrigerated overnight. This period of cold storage appeared to give the bacterial cells time to adhere to the surface of the meat, which offered some protection from heat (*59*). Therefore, depending on the level of *Campylobacter* contamination on chicken, some consumer practices for cooking large pieces of meat may be inadequate to kill all bacterial pathogens.

Several other processes have been tested for reducing *Campylobacter* loads on meat:

- Freezing of naturally contaminated chicken livers at -25ºC for 24 hours reduced *Campylobacter* levels by about 2 logs, but did not completely eliminate the pathogen (*108*).
- *Campylobacter* on the surface of chicken meat and on food contact surfaces is killed by high intensity near-UV light, but effectiveness is influenced by time of exposure and distance of light from the surface (*110*).
- Pulsed electric fields were found to reduce *Campylobacter* concentrations by about 4–7 logs in liquid media, but had no significant effect on *Campylobacter* on the surface of pieces of chicken (*112*).
- Some marinades applied to poultry meat can reduce contamination level of *Campylobacter* (*200, 258*).
- Packaging of chicken legs under a modified atmosphere (30% CO_2, 70% N_2) with a culture of *Bifidobacterium longum* caused only a 1.16 log decline in *Campylobacter* levels (*175*).

Raw milk is another important vehicle for campylobacteriosis. Outbreaks associated with raw milk have been increasing in the U.S. (*183*). A recent review summarized data on disease outbreaks associated with raw milk in the U.S. and regulations in states where outbreaks occurred (*153*). Unfortunately, people who believe that raw milk is healthier to consume than pasteurized milk often give raw milk to more vulnerable members of the population — young children and the elderly. A recent review summarized scientific evidence for the reported benefits of raw milk and for the presence of pathogens in unheated milk. With the exception of some alteration in the flavor of milk, pasteurization does not appear to affect the nutrients in milk, while it kills pathogenic bacteria (*51*). This information should be more widely disseminated.

Occupational exposure to *Campylobacter* can be reduced by better education of workers to reduce exposure and ensure better hygiene practices during and after handling animals. The National Association of State Public Health Veterinarians updated its recommendations for preventing disease associated with animals in public settings in 2013 (*270*). County fairs and petting zoos have been sites for a number of enteric disease outbreaks and procedures to protect children and the general public from becoming infected with *Salmonella* and *E. coli* also should protect them from *Campylobacter*.

Completely preventing *Campylobacter* contamination of meat and other foods is impossible, so food handlers and consumers should be educated about safe food preparation. Research has shown many persons preparing food at home either are unaware of or do not practice safe handling to prevent cross-contamination (*26, 117, 177*).

SUMMARY

Campylobacteriosis is a widespread food- and water-borne gastrointestinal illness, caused primarily by *C. jejuni* and *C. coli.* In most cases, morbidity is moderate, but in some cases, long term sequelae, including Guillain-Barré syndrome, reactive arthritis, and irritable bowel may persist for months or years. According to some estimates, about 30% of cases result from consumption and preparation of poultry meat. Unpasteurized milk and drinking water contaminated by sewage or run-off from fields also have been implicated in many outbreaks.

Although some smaller countries successfully have reduced their prevalence of campylobacteriosis,

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

many other countries have seen increasing or stable levels of this disease in spite of attempts to reduce contamination levels in poultry. Many surveys of retail poultry meat still find a large proportion carry *Campylobacter* (*274*). This review summarizes much of the latest information on campylobacteriosis and interventions being used or investigated to reduce contamination of food and water.

Figure 1.

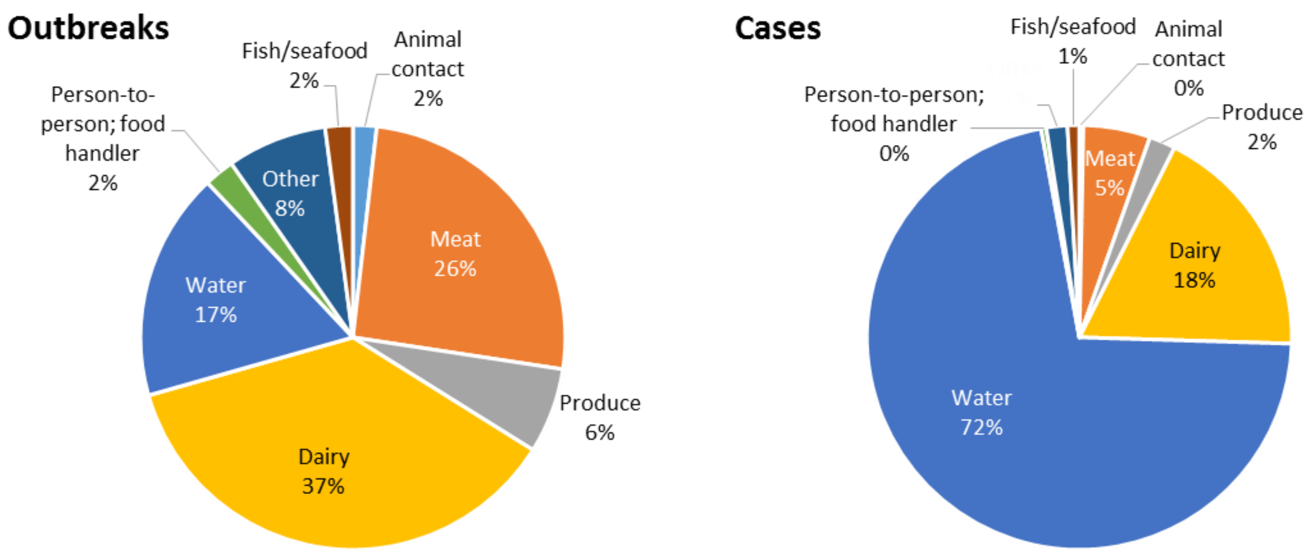

Figure 2. Vehicles (except for drinking water) associated with published reports of outbreaks and cases of *Campylobacter* infections.

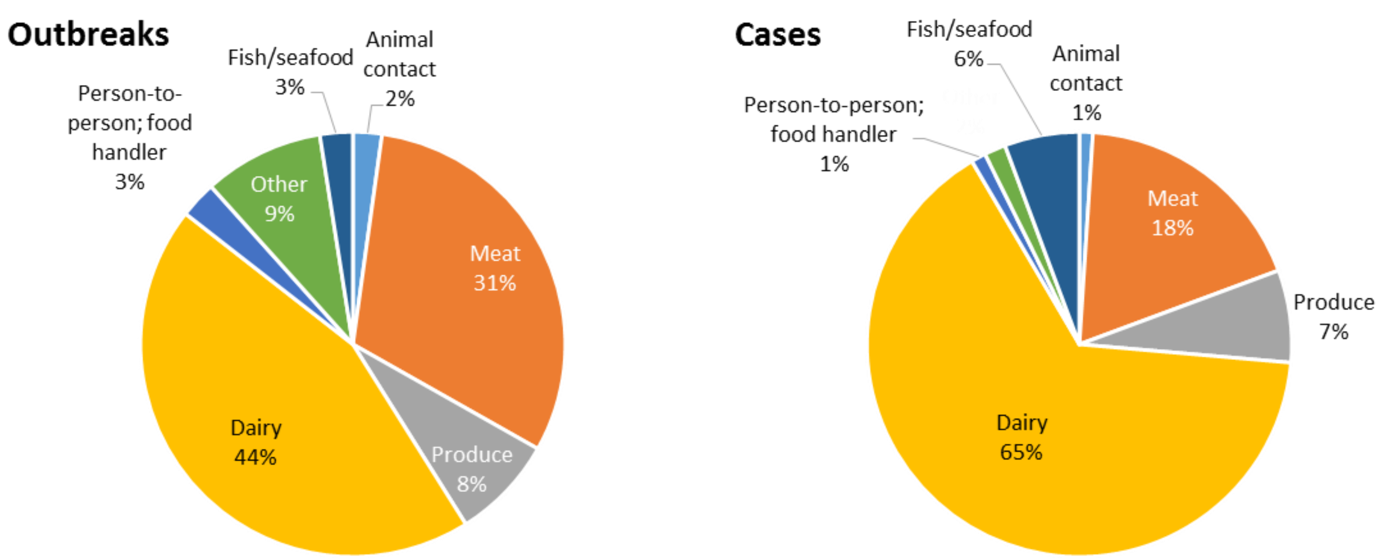

Figure 3. Different meat vehicles associated with published reports of outbreaks and cases of *Campylobacter* infections.

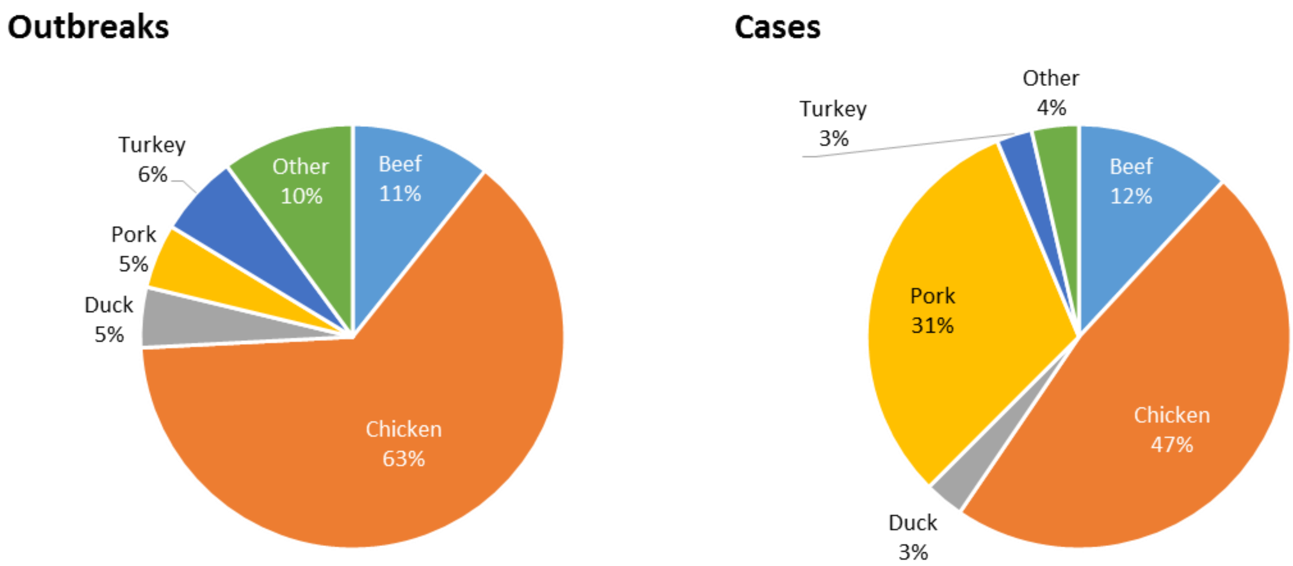

Table 1. Large foodborne outbreaks (>85 cases) of *Campylobacter*

Year	Cases	Species	Location; Vehicle	Reference
1979	3,500	*C. jejuni*	UK; raw milk	(*133, 216*)
2006	1,644	*C. jejuni*	US; pasteurized milk	(*47*)
1980	800	*C.* spp.	Japan: vinegared pork	(*284*)
1982	400	*C.* spp.	UK; raw milk	(*15*)
1938	357	*V. jejuni*	US; raw milk	(*157*)
1998	300	*C. jejuni*	US; lettuce	(*47*)
2008	268	*C. jejuni*	US; clams	(*47*)
2007	225	*C. jejuni*	Canada; mud	(*250*)
1981	208	*C.* spp.	US; raw milk	(*254*)
1979	205	*C.* spp.	Scotland; raw milk	(*205*)
2005	200	*C. jejuni*	US; pasteurized milk	(*47*)
2012	148	*C. jejuni*	US; raw milk	(*165*)
1981	145	*C.* spp.	UK; raw milk	(*15*)
1982	145	*C.* spp.	UK; raw milk	(*15*)
2002	136	*C. jejuni*	US; salads	(*47*)
2008	132	*C. jejuni*	US; peas	(*90*)
1998	128	*C. jejuni*	US; potato, pineapple, gravy	(*47*)
1992	110	*C. jejuni*	UK; raw milk	(*78*)
1978	100	*C.* spp.	UK; raw milk	(*216*)
2009	92	*C. jejuni*	Korea; chicken	(*288*)
1979–81	91	*C. jejuni*	US; raw milk	(*256*)
2005	86	*C. jejuni*	Scotland; chicken liver pâté	(*85*)
1980	86	*C.* spp.	UK; raw milk	(*257*)

Table 2. Large waterborne outbreaks (>400 cases) of *Campylobacter* reported in 1978 to 2013

Year	Cases	Species	Country	Contaminant	Reference
2007	6,500	*C. jejuni*, others	Finland	Cross-connection between sewage, drinking water pipes	(*150*)
1978	3,000	*C. jejuni*	US: VT	Agricultural runoff following heavy rain; inadequate chlorination	(*272*)
1995	3,000	*C.* spp.	Sweden	Unknown contamination of tap water	(*12*)
1998	2,700	*C.* spp.	Finland	Water main repairs	(*147*)
2000	2,600	*C. coli*, rotavirus, norovirus	France	Agricultural runoff; chlorination failure	(*89*)
1994	2,500	*C.* spp.	Sweden	Contaminated surface water source	(*12*)
2000	2,300	*C. jejuni*, *E. coli* O157:H7	Canada (Walkerton)	Agricultural runoff	(*52*)
1979	2,000	*C. jejuni*	Sweden	River water tainted drinking water because mains had no non-return valves; no chlorination	(*176*)
1998	1,607	*C. jejuni*, *Shigella*, norovirus	Switzerland	Pump failure spilling sewage into ground water	(*173*)
2004	1,450	*C. jejuni*, norovirus, *Giardia*, *Salmonella*	US: OH	Irregularities in sewage disposal contaminating ground water	(*196*)
1980	1,300	*C. jejuni*	US: CT	Inadequately treated reservoir water	(*32*)
2000	900	*C. jejuni*	Finland	Non-chlorinated groundwater supply	(*146*)
1983	865	*C. jejuni*	US: FL	Failure of chlorination; open top treatment towers with birds perching on top	(*222*)
1999	781	*C. jejuni*, *E. coli*	US: NY	Shallow well at county fair	(*194*)
1988	680	*C. jejuni*	Norway	Agricultural runoff; unchlorinated water	(*174*)
1995	633	*C.* spp., *E. coli*	UK	Contaminated stream water	(*132*)
2010	628	*C. jejuni*	US: UT	Cross-connection between potable and non-potable water sources	(*116*)
2010	409	*C. jejuni*	Denmark	Contamination of tap water	(*100*)

References

1. Acke E, McGill K, Golden O, Jones BR, Fanning S, Whyte P. 2009. Prevalence of thermophilic *Campylobacter* species in household cats and dogs in Ireland. *Vet Rec* 164: 44-47
2. Adhikari B, Connolly JH, Madie P, Davies PR. 2004. Prevalence and clonal diversity of *Campylobacter jejuni* from dairy farms and urban sources. *New Zealand Vet Journal* 52: 378-83
3. Food Standards Agency. 2014. Retail survey on levels of *Campylobacter* in chicken published. http://www.food.gov.uk/news-updates/news/2014/13251/campylobacter-survey
4. Aguiar VF, Donoghue AM, Arsi K, Reyes-Herrera I, Metcalf JH, de los Santos FS, Blore PJ, Donoghue DJ. 2013. Targeting motility properties of bacteria in the development of probiotic cultures against *Campylobacter jejuni* in broiler chickens. *Foodborne Pathog Dis* 10: 435-41
5. Agunos A, Léger D, Avery BP, Parmley EJ, Deckert A, Carson CA, Dutil L. 2013. Ciprofloxacin-resistant *Campylobacter* spp. in retail chicken, western Canada. *Emerg Infect Dis* 19: 1121-1124
6. Ahmed MFM, Schulz J, Hartung J. 2013. Survival of *Campylobacter jejuni* in naturally and artificially contaminated laying hen feces. *Poultry Sci* 92: 364-369
7. Ajene AN, Walker CLF, Black RE. 2013. Enteric pathogens and reactive arthritis: a systematic review of *Campylobacter*, *Salmonella* and *Shigella*-associated reactive arthritis. *J Health Popul Nutr* 31: 299-307
8. Al-Adwani SR, Crespo R, Shah DH. 2013. Production and evaluation of chicken egg-yolk-derived antibodies against *Campylobacter jejuni* colonization-associated proteins. *Foodborne Pathog Dis* 10: 624-631
9. Al Humam NA. 2013. Identification and characterisation of *Campylobacter* species from camel (*Camelus dromedarius*) in Al-Ahsa province of Saudi Arabia. *J Camel Practice Res* 20: 121-4
10. Allos BM, Blaser MJ. 1994. *Campylobacter jejuni* infection and the Guillain-Barré-syndrome — mechanisms and implications. *Int J Med Microbiol Virol Parasitol Infect Dis* 281: 544-548
11. Amar C, Kittl S, Spreng D, Thomann A, Korczak BM, Burnens AP, Kuhnert P. 2014. Genotypes and antibiotic resistance of canine *Campylobacter jejuni* isolates. *Vet Microbiol* 168: 124-130
12. Andersson Y, Dejong B, Studahl A. 1997. Waterborne *Campylobacter* in Sweden: the cost of an outbreak. *Water Sci Technol* 35: 11-14
13. Andrzejewska M, Szczepanska B, Klawe JJ, Spica D, Chudzinska M. 2013. Prevalence of *Campylobacter jejuni* and *Campylobacter coli* species in cats and dogs from Bydgoszcz (Poland) region. *Polish J Vet Sci* 16: 115-120
14. Annamalai T, Pina-Mimbela R, Kumar A, Binjawadagi B, Liu Z, Renukaradhya GJ, Rajashekara G. 2013. Evaluation of nanoparticle-encapsulated outer membrane proteins for the control of *Campylobacter jejuni* colonization in chickens. *Poultry Sci* 92: 2201-2211
15. Anon. 1984. Disease associated with milk and dairy products: 1982. *Brit Med J* 288: 466-467
16. Arsenault J, Letellier A, Quessy S, Boulianne M. 2007. Prevalence and risk factors for *Salmonella* and *Campylobacter* spp. carcass contamination in broiler chickens slaughtered in Quebec, Canada. *J Food Prot* 70: 1820-1828
17. Arsenault J, Letellier A, Quessy S, Morin JP, Boulianne M. 2007. Prevalence and risk factors for *Salmonella* and *Campylobacter* spp. carcass contamination in turkeys slaughtered in Quebec, Canada. *J Food Prot* 70: 1350-1359
18. Asakura H, Bruggemann H, Sheppard SK, Ekawa T, Meyer TF, Yamamoto S, Igimi S. 2012. Molecular evidence for the thriving of *Campylobacter jejuni* ST-4526 in Japan. *PLoS ONE* 7: e48394
19. Backhans A, Jacobson M, Hansson I, Lebbad M, Lambertz ST, Gammelgård E, Saager M, Akande O, Fellström C. 2013. Occurrence of pathogens in wild rodents caught on Swedish pig and chicken farms. *Epidemiol Infection* 141: 1885-1891
20. Badlik M, Holoda E, Pistl Jj, Koscova J, Sihelska Z. 2014. Prevalence of zoonotic *Campylobacter* spp. in rectal swabs from dogs in Slovakia: special reference to *C. jejuni* and *C. coli*. *Berlin Munch Tierarztl Wochenschr* 127: 144-148
21. Baer AA, Miller MJ, Dilger AC. 2013. Pathogens of interest to the pork industry: a review of research on interventions to assure food safety. *Comp Rev Food Sci Food Safety* 12: 183-217
22. Bahrndorff S, Rangstrup-Christensen L, Nordentoft S, Hald B. 2013. Foodborne disease prevention and broiler chickens with reduced *Campylobacter* infection. *Emerg Infect Dis* 19: 425-430
23. Baker J, Barton MD, Lanser J. 1999. *Campylobacter* species in cats and dogs in South Australia. *Austral Vet J* 77: 662-666
24. Barrett R. 2014. Raw milk blamed as 38 at Durand High football potluck are sickened. http://www.jsonline.com/business/raw-milk-blamed-as-38-at-durand-high-football-potluck-are-sickened-b99390272z1-282848161.html
25. Baumgartner A, Felleisen R. 2011. Market surveillance for contamination with thermotolerant campylobacters on various categories of chicken meat in Switzerland. *J Food Prot* 74: 2048-54
26. Bearth A, Cousin ME, Siegrist M. 2014. Poultry consumers' behaviour, risk perception and knowledge related to campylobacteriosis and domestic food safety. *Food Control* 44: 166-176
27. Bell C, Kyriakides A. 2009. *Campylobacter. A Practical Approach to the Organism and Its Control in Food*. 384pp. pp.
28. Bender JB, Shulman SA, Averbeck GA, Pantlin GC, Stromberg BE. 2005. Epidemiologic features of *Campylobacter* infection among cats in the upper midwestern United States. *J Am Vet Med Assoc* 226: 544-547
29. Biasi RS, De Macedo REF, Malaquias MAS, Franchin PR. 2011. Prevalence, strain identification and antimicrobial resistance of *Campylobacter* spp. isolated from slaughtered pig carcasses in Brazil. *Food Control* 22: 702-707
30. Bidewell CA, Woodger NGA, Cook AJC, Carson TV, Gale SL, Chanter JI, Williamson SM. 2010. *Campylobacter fetus* subspecies *fetus* abortion in alpacas (*Vicugna pacos*). *Vet Rec* 167: 457-458
31. Bilei S, Rodas EMF, Tolli R, De Santis P, Di Domenico I, Del Frate S, Palmieri P, Condoleo R. 2012. Prevalence of major pathogens on sheep carcasses slaughtered in Italy. *Ital J Food Sci* 24: 9-18
32. Blaser MJ, Reller LB. 1981. *Campylobacter* enteritis. *New Engl J Med* 305: 1444-1452
33. Boseret G, Losson B, Mainil JG, Thiry E, Saegerman C. 2013. Zoonoses in pet birds: review and perspectives. *Vet Res* 44: 36
34. Brandl MT, Haxo AF, Bates AH, Mandrell AE. 2004. Comparison of survival of *Campylobacter jejuni* in the phyllosphere with that in the rhizosphere of spinach and radish plants. *Appl Environ Microbiol* 70: 1182-1189
35. Bratz K, Goelz G, Riedel C, Janczyk P, Noeckler K, Alter T. 2013. Inhibitory effect of high-dosage zinc oxide dietary supplementation on *Campylobacter coli* excretion in weaned piglets. *J Appl Microbiol* 115: 1194-1202
36. Bremell T, Bjelle A, Svedhem Å. 1991. Rheumatic symptoms following an outbreak of *Campylobacter* enteritis — a 5-year follow-up. *Ann Rheumatic Dis* 50: 934-938
37. Brown HL, Reuter M, Salt LJ, Cross KL, Betts RP, van Vliet AHM. 2014. Chicken juice enhances surface attachment and biofilm formation of *Campylobacter jejuni*. *Appl Environ Microbiol* 80: 7053-7060
38. Buegener EM, Casteel M, Kump AWS, Klein G. 2014. Effect of electrolyzed oxidizing water on reducing *Campylobacter* spp. in broiler chicken at primary production. *J Food Safety Food Quality/Archiv fuer Lebensmittelhygiene* 65: 4-9
39. Bullman S, O'Leary J, Corcoran D, Sleator RD, Lucey B. 2012. Molecular-based detection of non-culturable and emerging *Campylobacteria* in patients presenting with gastroenteritis. *Epidemiol Infect* 140: 684-688
40. Burgess F, Little CL, Allen G, Williamson K, Mitchell RT. 2005. Prevalence of *Salmonella, Campylobacter,* and

Escherichia coli on the external packaging of raw meat. *J Food Prot* 68: 469-475

41. Burrough E, Terhorst S, Sahin O, Zhang QJ. 2013. Prevalence of *Campylobacter* spp. relative to other enteric pathogens in grow-finish pigs with diarrhea. *Anaerobe* 22: 111-114
42. Public Health Agency of Canada. 2014. 2013 Short report Foodnet Canada. HP37-17-1-2013-eng.pdf
43. Carbonero A, Paniagua J, Torralbo A, Arenas-Montes A, Borge C, Garcia-Bocanegra I. 2014. *Campylobacter* infection in wild artiodactyl species from southern Spain: occurrence, risk factors and antimicrobial susceptibility. *Comp Immunol Microbiol Infect Dis* 37: 115-121
44. Carbonero A, Torralbo A, Borge C, Garcia-Bocanegra I, Arenas A, Perea A. 2012. *Campylobacter* spp., *C. jejuni* and *C. upsaliensis* infection-associated factors in healthy and ill dogs from clinics in Cordoba, Spain. screening tests for antimicrobial susceptibility. *Comp Immunol Microbiol Infect Diseases* 35: 505-512
45. Carrillo CD, Plante D, Iugovaz I, Kenwell R, Belanger G, Boucher F, Poulin N, Trottier Y-L. 2014. Method-dependent variability in determination of prevalence of *Campylobacter jejuni* and *Campylobacter coli* in Canadian retail poultry. *J Food Prot* 10: 1682-1688
46. Carrique-Mas J, Andersson Y, Hjertqvist M, Sven A, Torner A, Giesecke J. 2005. Risk factors for domestic sporadic campylobacteriosis among young children in Sweden. *Scan J Infect Dis* 37: 101-110
47. Centers for Disease Control and Prevention. Foodborne Outbreak Online Database.
48. Chakeri A, Foroushani MSH, Torki Z, Rahimi E, Ebadi AG. 2012. Antimicrobial resistance of *Campylobacter* species isolated from fecal samples from cats and dogs in Iran. *J Pure Appl Microbiol* 6: 1823-1827
49. Choo LC, Saleha AA, Wai SS, Fauziah N. 2011. Isolation of *Campylobacter* and *Salmonella* from houseflies (*Musca domestica*) in a university campus and a poultry farm in Selangor, Malaysia. *Trop. Biomed.* 28: 16-20
50. Chowdhury S, Themudo GE, Sandberg M, Ersboll AK. 2013. Spatio-Temporal Patterns of *Campylobacter* Colonization in Danish Broilers. *Epidemiol Infect* 141: 997-1008
51. Claeys WL, Cardoen S, Daube G, De Block J, Dewettinck K, et al. 2013. Raw or heated cow milk consumption: review of risks and benefits. *Food Control* 31: 251-262
52. Clark CG, Price L, Ahmed R, Woodward DL, Melito PL, Rodgers FG, Jamieson F, Ciebin B, Li A, Ellis A. 2003. Characterization of waterborne outbreak-associated *Campylobacter jejuni*, Walkerton, Ontario. *Emerg Infect Dis* 9: 1232-1241
53. Colles FM, Maiden MCJ. 2012. *Campylobacter* sequence typing databases: applications and future prospects. *Microbiology-Sgm* 158: 2695-2709
54. Cook A, Reid-Smith R, Irwin Ra, McEwen SA, Valdivieso-Garcia A, Ribble C. 2009. Antimicrobial resistance in *Campylobacter*, *Salmonella*, and *Escherichia coli* isolated from retail turkey meat from southern Ontario, Canada. *J Food Protect* 72: 473-481
55. Cox NA, Richardson LJ, Berrang ME, Rigsby LL, Buhr RJ, Plumbee JR, Fedorka-Cray PJ. 2014. Survival of naturally occurring *Campylobacter* in refrigerated and frozen rinsate from a broiler carcass — a research note. *J Food Safety* 34: 76-78
56. Crim SM, Iwamoto M, Huang JY, Griffin PM, Gilliss D, Cronquist AB, Cartter M, Tobin-D'Angelo M, Blythe D, Smith, K, et al. 2014. Incidence and trends of infection with pathogens transmitted commonly through food — Foodborne Diseases Active Surveillance Network, 10 U.S. Sites, 2006–2013. *Morbid Mortal Weekly Rep* 63: 328-332
57. Cypierre A, Denes E, Barraud O, Jamilloux Y, Jacques J, Durox H, Pinet P, Weinbreck P. 2014. *Campylobacter fetus* infections. *Medecine et Maladies Infectieuses* 44: 167-173
58. De Cesare A, Valero A, Perez-Rodriguez F, Chemaly M, Manfreda G. 2015. Derivation of performance objectives for *Campylobacter* in broiler carcasses taking into account impact of selected factors on pathogen prevalence and counts. *Food Control* 47: 77-85
59. de Jong AEI, van Asselt ED, Zwietering MH, Nauta MJ, de Jonge R. 2012. Extreme heat resistance of food borne pathogens *Campylobacter jejuni*, *Escherichia coli*, and *Salmonella typhimurium* on chicken breast fillet during cooking. *Int J Microbiol* 2012: 196841
60. De Moura HM, Silva PR, Caldeira Da Silva PH, Souza NR, Racanicci AMC, Santana AP. 2013. Antimicrobial resistance of *Campylobacter jejuni* isolated from chicken carcasses in the Federal District, Brazil. *J Food Prot* 76: 691-693
61. Demirok E, Veluz G, Stuyvenberg WV, Castaneda MP, Byrd A, Alvarado CZ. 2013. Quality and safety of broiler meat in various chilling systems. *Poultry Sci* 92: 1117-1126
62. Denno DM, Keene WE, Hutter CM, Koepsell JK, Patnode M, Flodin-Hursh D, Stewart LK, Duchin JS, Rasmussen L, Jones R, Tarr PI. 2009. Tri-county comprehensive assessment of risk factors for sporadic reportable bacterial enteric infection in children. *J Infect Dis* 199: 467-476
63. Dicksved J, Ellstrom P, Engstrand L, Rautelin H. 2014. Susceptibility to *Campylobacter* infection is associated with the species composition of the human fecal microbiota. *mBio* 5: e01212-14
64. Dillehay DL, Paul KS, Boosinger TR, Fox JG. 1994. Enterocecocolitis associated with *Escherichia coli* and *Campylobacter*-like organisms in a hamster (*Mesocricetus auratus*) colony. *Lab Anim Sci* 44: 12-6
65. Dipineto L, Gargiulo A, Cuomo A, Santaniello A, Sensale M, Borrelli L, D'Angelo L, Menna LF, Fioretti A. 2009. *Campylobacter jejuni* in the red squirrel (*Sciurus vulgaris*) population of Southern Italy. *Vet J* 179: 149-510
66. Duffy EA, Belk DE, Sofos JN, Levalley SB, Kain ML, Tatum JD, Smith GC, Kimberling CV. 2001. Microbial contamination occurring on lamb carcasses processed in the United States. *J Food Prot* 64: 503-508
67. Eastmond CJ, Rennie JAN, Reid TMS. 1983. An outbreak of Campylobacter enteritis — a rheumatological follow-up survey. *J Rheumatol* 10: 107-108
68. ECDC Ea. 2014. The European Union summary report on trends and sources of zoonoses, zoonotic agents and food-borne outbreaks in 2012. *EFSA J* 12: 3547 [312pp.]
69. EFSA, ECDC. 2014. The European Union summary report on trends and sources of zoonoses, zoonotic agents, and foodborne outbreaks in 2012. *EFSA J* 12: 3547, 312 p.
70. El-Adawy H, Hotzel H, Duepre S, Tomaso H, Neubauer H, Hafez HM. 2012. Determination of antimicrobial sensitivities of *Campylobacter jejuni* isolated from commercial turkey farms in Germany. *Avian Dis* 56: 685-692
71. Ellis-Iversen J, Cook AJC, Smith RP, Pritchard GC, Nielen M. 2009. Temporal patterns and risk factors for *Escherichia coli* O157 and *Campylobacter* spp. in young cattle. *J Food Prot* 72: 490-6
72. Ellis A, Irwin R, Hockin J, Borczyk A, Woodward D, Johnson W. 1995. Outbreak of *Campylobacter* infection among farm workers: an occupational hazard. *Canada Commun Dis Rep* 21: 153-156
73. Ellstrom P, Hansson I, Soderstrom C, Engvall EO, Rautelin H. 2014. A prospective follow-up study on transmission of *Campylobacter* from poultry to abattoir workers. *Foodborne Pathog Dis* 11: 684-688
74. Elvers KT, Morris VK, Newell DG, Allen VM. 2011. Molecular tracking through processing of *Campylobacter* strains colonizing broiler flocks. *Appl Environ Microbiol* 77: 5722-5729
75. Ertas HB, Ozbey G, Kilic A, Muz A. 2003. Isolation of *Campylobacter jejuni* and *Campylobacter coli* from the gall bladder samples of sheep and identification by polymerase chain reaction. *J Vet Med Ser B-Infect Dis Vet Public Health* 50: 294-297
76. European Food Safety Authority. 2009. Assessing health benefits of controlling *Campylobacter* in the food chain. *EFSA J* 9: 2105
77. European Food Safety Authority, Control ECfDPa. 2014. The European Union summary report on antimicrobial resistance in zoonotic and indicator bacteria from humans, animals and food in 2012. *EFSA J* 12: 3590 (336 pp)

78. Fahey T, Morgan D, Gunneburg C, Adak GK, Majid F, Kaczmarski E. 1995. An outbreak of *Campylobacter jejuni* enteritis associated with failed milk pasteurization. *J Infect* 31: 137-143
79. Faiza SN, Saleha AA, Jalila A, Fauziah N. 2013. Occurrence of *Campylobacter* and *Salmonella* in ducks and duck eggs in Selangor, Malaysia. *Tropical Biomed* 30: 155-158
80. Fajo-Pascual M, Godoy P, Ferrero-Cancer M, Wymore K. 2010. Case-control study of risk factors for sporadic *Campylobacter* infections in northeastern Spain. *Eur J Public Health* 20: 443-448
81. Farmer S, Keenan A, Vivancos R. 2012. Food-borne *Campylobacter* outbreak in Liverpool associated with cross-contamination from chicken liver parfait: implications for investigation of similar outbreaks. *Public Health* 126: 657-659
82. Fernandez H, Oval A. 2013. Occurrence of *Campylobacter jejuni* and *Campylobacter coli* biotypes and antimicrobial susceptibility in healthy dogs in southern Chile. *Acta Sci Vet* 41
83. Fischer S, Kittler S, Klein G, Gluender G. 2013. Impact of a single phage and a phage cocktail application in broilers on reduction of *Campylobacter jejuni* and development of resistance. *PLoS ONE* 8: e78543
84. Food Standards Agency U. 2013. A refreshed strategy to reduce campylobacteriosis from poultry.
85. Forbes KJ, Gormley FJ, Dallas JF, Labovitiadi O, MacRae M, et al. 2009. *Campylobacter* immunity and coinfection following a large outbreak in a farming community. *J Clin Microbiol* 47: 111-116
86. Fullerton KE, Scallan E, Kirk MD, Mahon BE, Angulo FJ, de Valk H, van Pelt W, Gauci C, Hauri AM, Majowicz S, O'Brien S. 2012. Case-control studies of sporadic enteric infections: a review and discussion of studies conducted internationally from 1990 to 2009. *Foodborne Pathog Dis* 9: 281-292
87. Galanis E, Mak S, Otterstatter M, Taylor M, Zubel M, Takaro TK, Kuo M, Michel P. 2014. The association between campylobacteriosis, agriculture and drinking water: a case study in a region of British Columbia, Canada, 2005–2009. *Epidemiol Infect* 42: 2075-2084
88. Gallay A, Bousquet V, Siret V, Prouzet-Mauleon V, De Valk H, Vaillant V, Simon F, Le Strat Y, Mégraud F, Desenclos J-C. 2008. Risk factors for acquiring sporadic *Campylobacter* infection in France: results from a national case-control study. *J Infect Dis* 197: 1477-1484
89. Gallay A, De Valk H, Cournot M, Ladeuil B, Hemery C, Castor C, Bon F, Mégraud F, Le Cann P, Desenclos JC. 2006. A large multi-pathogen waterborne community outbreak linked to faecal contamination of a groundwater system, France, 2000. *Clin Microbiol Infect* 12: 561-570
90. Gardner TJ, Fitzgerald C, Xavier C, Klein R, Pruckler J, Stroika S, McLaughlin JB. 2011. Outbreak of campylobacteriosis associated with consumption of raw peas. *Clin Infect Dis* 53: 26-32
91. Gaudreau C, Helferty M, Sylvestre JL, Allard R, Pilon PA, Poisson M, Bekal S. 2013. *Campylobacter coli* outbreak in men who have sex with men, Quebec, Canada, 2010–2011. *Emerg Infect Dis* 19: 764-767
92. Giacomelli M, Piccirillo A. 2014. Pet reptiles as potential reservoir of *Campylobacter* species with zoonotic potential. *Vet Rec* 174: 479
93. Giacometti F, Bonilauri P, Serraino A, Peli A, Amatiste S, Arrigoni N, Bianchi M, Bilei S, Cascone G, Comin D, et al. 2013. Four-year monitoring of foodborne pathogens in raw milk sold by vending machines in Italy. *J Food Protect* 76: 1902-07
94. Goddard AD, Arnold ME, Allen VM, Snary EL. 2014. Estimating the time at which commercial broiler flocks in Great Britain become infected with *Campylobacter*: a Bayesian approach. *Epidemiol Infect* 142: 1884-1892
95. Gomez-Govea M, Solis-Soto L, Heredia N, Garcia S, Moreno G, Tovar O, Isunza G. 2012. Analysis of microbial contamination levels of fruits and vegetables at retail in Monterrey, Mexico. *J Food Agr Environ* 10: 152-156
96. Goossens H, Giesendorf BAJ, Vandamme P, Vlaes L, Van den Borre C, Koeken A, Quint WGV, Blomme W, Hanicq P, Koster DS, Hofstra H, Butzler J-P, Van der Plas J. 1995. Investigation of an outbreak of *Campylobacter upsaliensis* in day-care-centers in Brussels — analysis of relationships among isolates by phenotypic and genotypic typing methods. *J Infect Dis* 172: 1298-1305
97. Griekspoor P, Colles FM, Mccarthy ND, Hansbro PM, Ashhurst-Smith C, Olsen B, Hasselquist D, Maiden MCJ, Waldenström. 2013. Marked host specificity and lack of phylogeographic population structure of *Campylobacter jejuni* in wild birds. *Molec Ecol* 22: 1463-1472
98. Griekspoor P, Olsen B, Waldenström J. 2009. *Campylobacter jejuni* in penguins, Antarctica. *Emerg Infect Dis* 15: 847-849
99. Group OW. 2012. Monitoring the incidence and causes of diseases potentially transmitted by food in Australia: annual report of the OzFoodNet network, 2010. *Commun Dis Intell* 36: 213-40
100. Gubbels SM, Kuhn KG, Larsson JT, Adelhardt M, Engberg J, et al. 2012. A waterborne outbreak with a single clone of *Campylobacter jejuni* in the Danish town of Køge in May 2010. *Scan J Infect Dis* 44: 586-594
101. Guevremont E, Lamoureux L, Loubier CB, Villeneuve S, Dubuc J. 2014. Detection and characterization of *Campylobacter* spp. from 40 dairy cattle herds in Quebec, Canada. *Foodborne Pathogens Dis* 11: 388-394
102. Guyard-Nicodeme M, Tresse O, Houard E, Jugiau F, Courtillon C, El Manaa K, Laisney M-J, Chemaly M. 2013. Characterization of *Campylobacter* spp. transferred from naturally contaminated chicken legs to cooked chicken slices via a cutting board. *Int J Food Microbiol* 164: 7-14
103. Hakkinen M, Hanninen ML. 2009. Shedding of *Campylobacter* spp. in Finnish cattle on dairy farms. *J Appl Microbiol* 107: 898-905
104. Halbert LW, Kaneene JB, Ruegg PL, Warnick LD, Wells SJ, Mansfield LS, Fossler CP, Campbell AM, Geiger-Zwald AM. 2006. Evaluation of antimicrobial susceptibility patterns in *Campylobacter* spp isolated from dairy cattle and farms managed organically and conventionally in the midwestern and northeastern United States. *J Am Vet Med Assoc* 228: 1074-1081
105. Hamedy A, Fehlhaber K, Alter T, Gluender G. 2013. Occurrence of genetic diversity and differentiation of *Campylobacter* in poultry flocks. *Fleischwirtschaft* 93: 90-95
106. Hara-Kudo Y, Takatori K. 2011. Contamination level and ingestion dose of foodborne pathogens associated with infections. *Epidemiol Infection* 139: 1505-1510
107. Harder-Lauridsen NM, Kuhn KG, Erichsen AC, Mølbak K, Ethelberg S. 2013. Gastrointestinal illness among triathletes swimming in non-polluted versus polluted seawater affected by heavy rainfall, Denmark, 2010–2011. *PLoS ONE* 8: e78371
108. Harrison D, Corry JEL, Tchorzewska MA, Morris VK, Hutchison ML. 2013. Freezing as an intervention to reduce the numbers of campylobacters isolated from chicken livers. *Lett Appl Microbiol* 57: 206-213
109. Haruna M, Sasaki Y, Murakami M, Ikeda A, Kusukawa M, Tsujiyama Y, Ito K, Asai T, Yamada Y. 2012. Prevalence and antimicrobial susceptibility of *Campylobacter* in broiler flocks in Japan. *Zoonoses Public Health* 59: 241-245
110. Haughton PN, Grau EG, Lyng J, Cronin D, Fanning S, Whyte P. 2012. Susceptibility of *Campylobacter* to high intensity near ultraviolet/visible 395 ± 5 nm light and its effectiveness for the decontamination of raw chicken and contact surfaces. *Int J Food Microbiol* 159: 267-273
111. Haughton PN, Lyng J, Fanning S, Whyte P. 2013. Potential of a commercially available water acidification product for reducing *Campylobacter* in broilers prior to slaughter. *Brit Poultry Sci* 54: 319-324
112. Haughton PN, Lyng JG, Cronin DA, Morgan DJ, Fanning S, Whyte P. 2012. Efficacy of pulsed electric fields for the inactivation of indicator microorganisms and foodborne pathogens in liquids and raw chicken. *Food Control* 25: 131-135
113. Hazeleger WC, Bolder NM, Beumer RR, Jacobs-Reitsma WF. 2008. Darkling beetles (*Alphitobius diaperinus*) and their

larvae as potential vectors for the transfer of *Campylobacter jejuni* and *Salmonella* Enterica serovar Paratyphi B variant Java between successive broiler flocks. *Appl Environ Microbiol* 74: 6887-6891
114. Australian Government Department of Health. 2014. National notifiable diseases surveillance system. http://www9.health.gov.au/cda/source/cda-index.cfm. Accessed October 2014
115. Hershkowicz S, Barak M, Cohen A, Montag J. 1987. An outbreak of *Campylobacter jejuni* infection in a neonatal intensive care unit. *J Hosp Infect* 9: 54-59
116. Hilborn ED, Wade TJ, Hicks L, Garrison L, Carpenter J, Adam E, Mull B, Yoder J, Roberts V, Garganzo JW. 2013. Surveillance for waterborne disease outbreaks associated with drinking water and other nonrecreational water — United States, 2009–2010. *Morbid Mortal Weekly Rep* 62: 714-720
117. Hoelzl C, Mayerhofer U, Steininger M, W. B, Hofstadter D, Aldrian U. 2013. Observational trial of safe food handling behavior during food preparation using the example of *Campylobacter* spp. *J Food Prot* 76: 482-489
118. Hoffmann S, Batz MB, Morris JG. 2012. Annual cost of illness and quality-adjusted life year losses in the United States due to 14 foodborne pathogens. *J Food Prot* 75: 1292-1302
119. Horn BJ, Lake RJ. 2013. Incubation period for campylobacteriosis and its importance in the estimation of incidence related to travel. *Euro Surv* 18: 17-22
120. Hrudey SE, Hrudey EJ. 2007. Published case studies of waterborne disease outbreaks — evidence of a recurrent threat. *Water Environ Res* 79: 233-245
121. Hudson SJ, Lightfoot NF, Coulson JC, Russell K, Sisson PR, Sobo AO. 1991. Jackdaws and magpies as vectors of milkborne human *Campylobacter* infection. *Epidemiol Infect* 107: 363-372
122. Humphrey S, Chaloner G, Kemmett K, Davidson N, Williams N, Kipar A, Humphrey T, Wigley P. 2014. *Campylobacter jejuni* is not merely a commensal in commercial broiler chickens and affects bird welfare. *mBio* 5: e01364-14
123. Hunter DB, Prescott JF, Pettit JR, Snow WE. 1983. *Campylobacter jejuni* as a cause of abortion in mink. *Can Vet J* 24: 398-399
124. Inglis GD, Morck DW, Mcallister TA, Entz T, Olson ME, Yanke LJ, Read RR. 2006. Temporal prevalence of antimicrobial resistance in *Campylobacter* spp. from beef cattle in Alberta feedlots. *Appl Environ Microbiol* 72: 4088-4095
125. Islam Z, Gilbert M, Mohammad Q, Klaij K, Li J, van Rijs W, Tio-Gillen AP, Talukder KA, Willison HJ, van Belkum A, Endtz HP, Jacobs BC. 2012. Guillain-Barré Syndrome-related *Campylobacter jejuni* in Bangladesh: ganglioside mimicry and cross-reactive antibodies. *PLoS ONE* 7: e43976
126. Jackson BR, Alomía Zegarra J, López-Gatell H, Sejvar J, Arzate F, Waterman S, Sánchez Núñez A, López B, Weiss J, Quintero Cruz R, et al. 2013. Binational outbreak of Guillain-Barré syndrome associated with *Campylobacter jejuni* infection, Mexico and USA, 2011. *Epidemiol Infect* 142: 1089-1099
127. Jay-Russell MT, Bates A, Harden L, Miller WG, Mandrell RE. 2012. Isolation of *Campylobacter* from feral swine (*Sus scrofa*) on the ranch associated with the 2006 *Escherichia coli* O157:H7 Spinach outbreak investigation in California. *Zoonoses Public Health* 59: 314-319
128. Jayarao BM, Donaldson SC, Straley BA, Sawant AA, Hegde NV, Brown JL. 2006. A survey of foodborne pathogens in bulk tank milk and raw milk consumption among farm families in Pennsylvania. *J Dairy Sci* 89: 2451-2458
129. Jayarao BM, Henning DR. 2001. Prevalence of foodborne pathogens in bulk tank milk. *J Dairy Sci* 84: 2157-2162
130. Jensen AN, Hansen LL, Baggesen DL, Molbak L. 2013. Effects of feeding finisher pigs with chicory or lupine feed for one week or two weeks before slaughter with respect to levels of *Bifidobacteria* and *Campylobacter*. *Animal* 7: 66-74
131. Jolley K. 2014. *Campylobacter* MLST Home Page. ed. A Cody, F Colles, W Miller. University of Ozford: Wellcome Trust. http://pubmlst.org/campylobacter/Accessed November 2014
132. Jones IG, Roworth M. 1996. An outbreak of *Escherichia coli* O157 and campylobacteriosis associated with contamination of a drinking water supply. *Public Health* 110: 277-282
133. Jones PH, Willis AT, Robinson DA, Skirrow MB, Josephs DS. 1981. *Campylobacter* enteritis associated with the consumption of free-school milk. *J Hyg* 87: 155-162
134. Kaakoush NO, Castano-Rodriguez N, Day AS, Lemberg DA, Leach ST, Mitchell HM. 2014. *Campylobacter concisus* and exotoxin 9 levels in paediatric patients with Crohn's disease and their association with the intestinal microbiota. *J Med Microbiol* 63: 99-105
135. Kärenlampi R, L. HM. 2004. Survival of *Campylobacter jejuni* on various fresh produce. *Int J Food Microbiol* 97: 187-195
136. Keller JI, Shriver WG. 2014. Prevalence of three *Campylobacter* species, *C. jejuni*, *C. coli*, and *C. lari*, using multilocus sequence typing in wild birds of the Mid-Atlantic region, USA. *J Wildlife Dis* 50: 31-41
137. Khan MS. 1982. An epidemiological study of a *Campylobacter* enteritis outbreak involving dogs and man. In *Campylobacter. Epidemiology, Pathogenesis and Biochemistry*, ed. DG Newell, pp. 256-257. Boston: MTP Press
138. Kittl S, Heckel G, Korczak BM, Kuhnert P. 2013. Source attribution of human *Campylobacter* isolates by MLST and fla-typing and association of genotypes with quinolone resistance. *PLoS ONE* 8: e81796
139. Kittler S, Fischer S, Abdulmawjood A, Glunder G, Klein G. 2014. Colonisation of a phage susceptible *Campylobacter jejuni* population in two phage positive broiler flocks. *PLoS ONE* 9: e94782
140. Kittler S, Fischer SY, Abdulmawjood A, Glunder G, Klein G. 2013. Effect of bacteriophage application on *Campylobacter jejuni* loads in commercial broiler flocks. *Appl Environ Microbiol* 79: 7525-7533
141. Klancnik A, Mozina SS, Zhang QJ. 2012. Anti-*Campylobacter* activities and resistance mechanisms of natural phenolic compounds in *Campylobacter*. *PLoS ONE* 7: e51800
142. Klein D, Alispahic M, Sofka D, Iwersen M, Drillich M, Hilbert F. 2013. Prevalence and risk factors for shedding of thermophilic *Campylobacter* in calves with and without diarrhea in Austrian dairy herds. *J Dairy Sci* 96: 1203-1210
143. Kothary MH, Babu US. 2001. Infective dose of foodborne pathogens in volunteers: a review. *J Food Safety* 21: 49-73
144. Koziel M, Corcoran GD, Sleator RD, Lucey B. 2014. Detection and molecular analysis of *Campylobacter ureolyticus* in domestic animals. *Gut Pathogens* 6: 9
145. Koziel M, Lucey B, Bullman S, Corcoran GD, Sleator RD. 2012. Molecular-based detection of the gastrointestinal pathogen *Campylobacter ureolyticus* in unpasteurized milk samples from two cattle farms in Ireland. *Gut Pathogens* 4: 14
146. Kuusi M, Klemets P, Miettinen I, Laaksonen I, Sarkkinen H, Hänninen ML, Rautelin H, Kela E, Nuorti JP. 2004. An outbreak of gastroenteritis from a non-chlorinated community water supply. *J Epidemiol Commun Health* 58: 273-277
147. Kuusi M, Nuorti JP, Hänninen ML, Koskela M, Jussila V, Kela E, Miettinen I, Ruutu P. 2005. A large outbreak of campylobacteriosis associated with a municipal water supply in Finland. *Epidemiol Infect* 133: 593-601
148. Kwan PL, Xavier C, Santovenia M, Pruckler J, Stroika S, Joyce K, Gardner T, Fields PI, McLaughlin J, Tauxe RV, Fitzgerald C. 2014. Multilocus sequence typing confirms wild birds as the source of a *Campylobacter* outbreak associated with consumption of raw peas. *Appl Environ Microbiol* 80: 4540-4546
149. Kwan PSL, Birtles A, Bolton FJ, French NP, Robinson SE, Newbold LS, Upton M, Fox AJ. 2008. Longitudinal study of the molecular epidemiology of *Campylobacter jejuni* in cattle on dairy farms. *Appl Environ Microbiol* 74: 3626-3633
150. Laine J, Huovinen E, Virtanen MJ, Snellman M, Lumio J, Ruutu P, Kujansuu E, Vuento R, Pitkänen T, Miettinen I, et al. 2011. An extensive gastroenteritis outbreak after drinking-

water contamination by sewage effluent, Finland. *Epidemiol Infect* 139: 1105-1113

151. Laine J, Lumio J, Toikkanen S, Virtanen MJ, Uotila T, Korpela M, Kujansuu E, Kuusi M. 2014. The duration of gastrointestinal and joint symptoms after a large waterborne outbreak of gastroenteritis in Finland in 2007 — A questionnaire-based 15-month follow-up study. *PLoS ONE* 9: e85457
152. Lake RJ, Horn BJ, Dunn AH, Parris R, Green FT, McNickle DC. 2013. Cost-effectiveness of interventions to control *Campylobacter* in the New Zealand poultry meat food supply. *J Food Prot* 76: 1161-1167
153. Langer A, Ayers T, Grass J, Lynch M, Angulo FJ, Mahon BE. 2012. Nonpasteurized dairy products, disease outbreaks, and state laws — United States, 1993–2006. *Emerg Infect Dis* 18: 385-391
154. Lazou T, Dovas C, Houf K, Soultos N, Iossifidou E. 2014. Diversity of *Campylobacter* in retail meat and liver of lambs and goat kids. *Foodborne Pathog Dis* 11: 320-328
155. Lazou T, Houf K, Soultos N, Dovas C, Iossifidou E. 2014. *Campylobacter* in small ruminants at slaughter: prevalence, pulsotypes and antibiotic resistance. *Int J Food Microbiol* 173: 54-61
156. Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. 2002. Surveillance for waterborne-disease outbreaks — United States, 1999–2000. *Morbid Mortal Weekly Rep* 51: 1-47
157. Levy AJ. 1946. A gastro-enteritis outbreak probably due to a bovine strain of *Vibrio*. *Yale J Biol Med* 18: 243-255
158. Levy DA, Bens MS, Craun GF, Calderon RL, Herwaldt BL. 1998. Surveillance for waterborne-disease outbreaks: United States, 1995–1996. *Morbid Mortal Weekly Rep* 47: 1-34
159. Ley EC, Morishita TY, Brisker T, Harr BS. 2001. Prevalence of *Salmonella*, *Campylobacter*, and *Escherichia coli* on ostrich carcasses and the susceptibility of ostrich-origin *E. coli* isolates to various antibiotics. *Avian Dis* 45: 696-700
160. Lienau JA, Ellerbroek L, Klein G. 2007. Tracing flock-related *Campylobacter* clones from broiler farms through slaughter to retail products by pulsed field gel electrophoresis. *J Food Prot* 70: 536-542
161. Lim E, Lopez L, Borman A, Cressey P, Pirie R. 2012. Foodborne disease in New Zealand 2011.
162. Llarena AK, Sivonen K, Hanninen ML. 2014. *Campylobacter jejuni* prevalence and hygienic quality of retail bovine ground meat in Finland. *Lett Appl Microbiol* 58: 408-413
163. Locht H, Krogfelt KA. 2002. Comparison of rheumatological and gastrointestinal symptoms after infection with *Campylobacter jejuni/coli* and enterotoxigenic *Escherichia coli*. *Ann Rheumat Diss* 61: 448-452
164. Lohmus M, Albihn A. 2013. Gastrointestinal pathogens in rodents overwintering in human facilities around Uppsala, Sweden. *J Wildlife Diseases* 49: 747-749
165. Longenberger AH, Palumbo AJ, Chu AK, Moll ME, Weltman A, Ostroff SM. 2013. *Campylobacter jejuni* infections associated with unpasteurized milk-multiple states, 2012. *Clin Infect Dis* 57: 263-266
166. Luber P, Brynestad S, Topsch D, Scherer K, Bartelt E. 2006. Quantification of *Campylobacter* species cross-contamination during handling of contaminated fresh chicken parts in kitchens. *Appl Environ Microbiol* 72: 66-70
167. Maesaar M, Praakle K, Meremae K, Kramarenko T, Sogel J, Viltrop A, Muutra K, Kovalenko K, Matt D, Hörman A, et al. 2014. Prevalence and counts of *Campylobacter* spp. in poultry meat at retail level in Estonia. *Food Control* 44: 72-77
168. Man SM. 2011. The clinical importance of emerging *Campylobacter* species. *Nature Rev Gastroenterol Hepatol* 8: 669-685
169. Mannering SA, Marchant RM, Middelberg A, Perkins NR, West DM, Fenwick SG. 2003. Pulsed-field gel electrophoresis typing of *Campylobacter fetus* subsp *fetus* from sheep abortions in the Hawke's Bay region of New Zealand. *New Zealand Vet J* 51: 33-37
170. Mansouri-Najand L, Saleha AA, Wai SS. 2012. Prevalence of multidrug resistance *Campylobacter jejuni* and *Campylobacter coli* in chickens slaughtered in selected markets, Malaysia. *Tropical Biomed* 29: 231-238
171. Marin C, Ingresa-Capaccioni S, Gonzalez-Bodi S, Marco-Jimenez F, Vega S. 2013. Free-living turtles are a reservoir for *Salmonella* but not for *Campylobacter*. *PLoS ONE* 8:e72350
172. Matt M, Mann M. 2014. Recurrent *Campylobacter* detection in salad at a kebab shop. *Arch Lebensmittelhyg* 65: 50-53
173. Maurer AM, Sturchler D. 2000. A waterborne outbreak of small round structured virus, *Campylobacter* and *Shigella* co-infections in La Neuveville, Switzerland, 1998. *Epidemiol Infect* 125: 325-332
174. Melby K, Gondrosen B, Gregusson S, Ribe H, Dahl OP. 1991. Waterborne campylobacteriosis in northern Norway. *Int J Food Microbiology* 12: 151-156
175. Melero B, Juntunen P, Hanninen ML, Jaime I, Rovira J. 2012. Tracing *Campylobacter jejuni* strains along the poultry meat production chain from farm to retail by pulsed-field gel electrophoresis, and the antimicrobial resistance of isolates. *Food Microbiol* 32: 124-128
176. Mentzing LO. 1981. Waterborne outbreaks of *Campylobacter* enteritis in central Sweden. *Lancet* 2: 352-354
177. Millman C, Rigby D, Edward-Jones G, Lighton L, Jones DM. 2014. Perceptions, behaviours and kitchen hygiene of people who have and have not suffered campylobacteriosis: A case control study. *Food Control* 41: 82-90
178. Molina-Lopez RA, Valveru N, Martin M, Mateu E, Obon E, Cerdà-Cuéller M, Darwich L. 2011. Wild raptors as carriers of antimicrobial-resistant *Salmonella* and *Campylobacter* strains. *Vet Rec* 168: 565
179. Møller-Stray J, Eriksen HM, Bruheim T, Kapperud G, Lindstedt BA, Skeie Å, Sunde M, Urdahl AM, Øygard B, Vold L. 2012. Two outbreaks of diarrhoea in nurseries in Norway after farm visits, April to May 2009. *Eurosurveillance* 17: 20-26
180. Moore JE, Madden RH. 2001. Survival of *Campylobacter coli* in porcine liver. *Food Microbiol* 18: 1-10
181. Mpalang RKA, Boreux R, Melin P, Bitiang KAN, Daube G, Mol Pd. 2014. Prevalence of *Campylobacter* among goats and retail goat meat in Congo. *J Infect Developing Countries* 8: 168-175
182. Mughini Gras L, Smid JH, Wagenaar JA, Koene MGJ, Havelaar AH, Friesema IHM, French NP, Flemming C, Galson JD, Graziani C, et al. 2013. Increased risk for *Campylobacter jejuni* and *C. coli* infection of pet origin in dog owners and evidence for genetic association between strains causing infection in humans and their pets. *Epidemiol Infection* 141: 2526-2535
183. Mungai EA, Behravesh CB, Gould LH. 2015. Increased outbreaks associated with nonpasteurized milk, United States, 2007–2012. *Emerg Infect Dis* 21: 119-122
184. Musavian HS, Krebs NH, Nonboe U, Corry JEL, Purnell G. 2014. Combined steam and ultrasound treatment of broilers at slaughter: a promising intervention to significantly reduce numbers of naturally occurring campylobacters on carcasses. *Int J Food Microbiol* 176: 23-28
185. Nathues C, Grüning P, Fruth A, Verspohl J, Blaha T, Kreienbrock L, Merle R. 2013. *Campylobacter* spp., *Yersinia enterocolitica*, and *Salmonella enterica* and their simultaneous occurrence in German fattening pig herds and their environment. *J Food Prot* 76: 1704-1711
186. National Antimicrobial Resistance Monitoring Data. 2011. Animal Component Data Updates. http://www.ars.usda.gov/Main/docs.htm?docid=14491 Accessed October 2012.
187. Neimann J, Engberg J, Molbak K, Wegener HC. 2003. A case-control study of risk factors for sporadic *Campylobacter* infections in Denmark. *Epidemiol Infect* 130: 353-366
188. Ngotho M, Ngure RM, Kamau DM, Kagira JM, Gichuki CO, Farah IO, Sayer PD, Hau J. 2006. A fatal outbreak of *Campylobacter jejuni* enteritis in a colony of vervet monkeys in Kenya. *Scan J Lab Anim Sci* 33: 205-210
189. Nielsen HL, Engberg J, Ejlertsen T, Nielsen H. 2013. Clinical manifestations of *Campylobacter concisus* infection in children. *Pediatr Infect Dis J* 32: 1194-1198
190. Nielsen HL, Engberg J, Ejlertsen T, Nielsen H. 2014. Psychometric scores and persistence of irritable bowel after

Campylobacter concisus infection. *Scan J Gastroenterol* 49: 545-551

191. Nonga HE, Muhairwa AP. 2010. Prevalence and antibiotic susceptibility of thermophilic *Campylobacter* isolates from free range domestic duck (*Cairina moschata*) in Morogoro municipality, Tanzania. *Trop Animal Health Prod* 42: 165-172
192. Noormohamed A, Fakhr MK. 2012. Incidence and antimicrobial resistance profiling of *Campylobacter* in retail chicken livers and gizzards. *Foodborne Path Dis* 9: 617-624
193. Noormohamed A, Fakhr MK. 2013. A higher prevalence rate of *Campylobacter* in retail beef livers compared to other beef and pork meat cuts. *Int J Environ Res Public Health* 10: 2058-2068
194. Novello A. 1999. Outbreak of *Escherichia coli* O157:H7 and *Campylobacter* among attendees of the Washington County fair — New York, 1999. *Morbid Mortal Weekly Rep* 48: 803-805
195. Nygård K, Andersson Y, Røttingen JA, Svensson Å, Lindbäck J, et al. 2004. Association between environmental risk factors and *Campylobacter* infections in Sweden. *Epidemiol Infect* 132: 317-325
196. O'Reilly CE, Bowen AB, Perez NE, Sarisky JP, Shepherd CA, Miller MD, Hubbard BC, Herring M, Buchanan SD, Fitzgerald CC, et al. 2007. A waterborne outbreak of gastroenteritis with multiple etiologies among resort island visitors and residents: Ohio, 2004. *Clin Infect Dis* 44: 506-512
197. Orr KE, Lightfoot NF, Sisson PR, Harkis BA, Tweddle JL, Boyd P, Carroll A, Jackson CJ, Wareing DRA, Freeman R. 1995. Direct milk excretion of *Campylobacter jejuni* in a dairy-cow causing cases of human enteritis. *Epidemiol Infect* 114: 15-24
198. Pao S, Hagens BE, Kim C, Wildeus S, Ettinger MR, Wilson MD, Watts BD, Whitley NC, Porto-Fett ACS, Schwarz JG, et al. 2014. Prevalence and molecular analyses of *Campylobacter jejuni* and *Salmonella* spp. in co-grazing small ruminants and wild-living birds. *Livestock Sci* 160: 163-171
199. Park CE, Sanders GW. 1992. Occurrence of thermotolerant campylobacters in fresh vegetables sold at farmers outdoor markets and supermarkets. *Can J Microbiol* 38: 313-316
200. Park NY, Hong SH, Yoon KS. 2014. Effects of commercial marinade seasoning and a natural blend of cultured sugar and vinegar on *Campylobacter jejuni* and *Salmonella Typhimurium* and the texture of chicken breasts. *Poultry Sci* 93: 719-727
201. Patrick M, Gilbert MJ, Blaser MJ, Tauxe RV, Wagenaar JA, Fitzgerald C. 2013. Human infections with new subspecies of *Campylobacter fetus*. *Emerg Infect Dis* 19: 1678-1680
202. Pazzaglia G, Widjaja S, Soebekti D, Tjaniadi P, Simanjuntak L, Lesmana M, Jennings G. 1994. Persistent, recurring diarrhea in a colony of orangutans (*Pongo pygmaeus*) caused by multiple strains of *Campylobacter* spp. *Acta Tropica* 57: 1-10
203. Phillips D, Tholath S, Jenson I, Sumner J. 2013. Microbiological quality of Australian sheep meat in 2011. *Food Control* 31: 291-294
204. Pike BL, Guerry P, Poly F. 2013. Global distribution of *Campylobacter jejuni* Penner serotypes: a systematic review. *PLoS ONE* 8: e67375
205. Porter IA, Reid TMS. 1980. A milk-borne outbreak of *Campylobacter* infection. *J Hyg* 84: 415-9
206. Centers for Disease Control and Prevention. 2013. Antibiotic resistance threats in the United States, 2013. http://www.cdc.gov/drugresistance/threat-report-2013/ Accessed September 2013
207. Procter TD, Pearl DL, Finley RL, Leonard EK, Janecko N, Reid-Smith RJ, Weese JS, Peregrine AS, Sargeant JM. 2014. A cross-sectional study examining *Campylobacter* and other zoonotic enteric pathogens in dogs that frequent dog parks in three cities in South-Western Ontario and risk factors for shedding of *Campylobacter* spp. *Zoonoses Public Health* 61: 208-218
208. Qin SS, Wu CM, Wang Y, Jeon B, Shen ZQ, Wang Y, Zhang Q, Shen J-Z. 2011. Antimicrobial resistance in *Campylobacter coli* isolated from pigs in two provinces of China. *Int J Food Microbiol* 146: 94-8
209. Rahimi E, Sepehri S, Momtaz H. 2013. Prevalence of *Campylobacter* species in milk and dairy products in Iran. *Rev Med Vet* 164: 283-288
210. Rapp D, Ross CM, Cave V, Muirhead RW. 2014. Prevalence, concentration and genotypes of *Campylobacter jejuni* in faeces from dairy herds managed in farm systems with or without housing. *J Appl Microbiol* 116: 1035-1043
211. Rasschaert G, Piessens V, Scheldeman P, Leleu S, Stals A, Herman L, Heyndrickx, Messens W. 2013. Efficacy of electrolyzed oxidizing water and lactic acid on the reduction of *Campylobacter* on naturally contaminated broiler carcasses during processing. *Poultry Sci* 92: 1077-1084
212. Revez J, Rossi M, Piva S, Florio D, Lucchi A, Parisi A, Manfreda G, Zanoni RG. 2013. Occurrence of ε-proteobacterial species in rabbits (*Oryctolagus cuniculus*) reared in intensive and rural farms. *Vet Microbiol* 162: 288-292
213. Riazi A, Strong PCR, Coleman R, Chen WX, Hirama T, van Faassen H, Henry M, Logan SM, Szymanski CM, MacKenzi R, et al. 2013. Pentavalent single-domain antibodies reduce *Campylobacter jejuni* motility and colonization in chickens. *PLoS ONE* 8: e83928
214. Riddle MS, Murray JA, Cash BD, Pimentel M, Porter CK. 2013. Pathogen-specific risk of celiac disease following bacterial causes of foodborne illness: a retrospective cohort study. *Digest Dis Sci* 58: 3242-3245
215. Robinson DA. 1981. Infective dose of *Campylobacter jejuni* in milk. *Brit Med J* 282: 1584
216. Robinson DA, Jones DM. 1981. Milk-borne *Campylobacter* infection. *Brit Med J* 282: 1374-76
217. Robinson TJ, Scheftel JM, Smith KE. 2013. Raw milk consumption among patients with non-outbreak-related enteric infections, Minnesota, USA, 2001–2010. *Emerg Infect Dis* 20: 38-44
218. Robyn J, Rasschaert G, Hermans D, Pasmans F, Heyndrickx M. 2013. In vivo broiler experiments to assess anti-*Campylobacter jejuni* activity of a live *Enterococcus faecalis* strain. *Poultry Sci* 92: 265-271
219. Rosenquist H, Boysen L, Krogh AL, Jensen AN, Nauta M. 2013. *Campylobacter* contamination and the relative risk of illness from organic broiler meat in comparison with conventional broiler meat. *Int J Food Microbiol* 162: 226-230
220. Rutledge ME, Siletzky RM, Gu WM, Degernes LA, Moorman CE, DePerno CS, Kathariou S. 2013. Characterization of *Campylobacter* from resident Canada geese in an urban environment. *J Wildlife Dis* 49: 1-9
221. Ruusunen M, Salonen M, Pulkkinen H, Huuskonen M, Hellstrom S, et al. 2013. Pathogenic bacteria in Finnish bulk tank milk. *Foodborne Pathog Dis* 10: 99-106
222. Sacks JJ, Lieb S, Baldy LM, Berta S, Patton CM, White MC, Bigler WJ, Witte JJ. 1986. Epidemic campylobacteriosis associated with a community water supply. *Am J Public Health* 76: 424-429
223. Sahin O, Fitzgerald C, Stroika S, Zhao S, Sippy RJ, Kwan Patrick, Plummer PJ, Han J, Yaeger MJ, Zhang Q. 2012. Molecular evidence for zoonotic transmission of an emergent, highly pathogenic *Campylobacter jejuni* clone in the United States. *J Clin Microbiol* 50: 680-687
224. Sandberg M, Bergsjo B, Hofshagen M, Skjerve E, Kruse H. 2002. Risk factors for *Campylobacter* infection in Norwegian cats and dogs. *Prev Vet Med* 55: 241-253
225. Sasaki Y, Goshima T, Mori T, Murakami M, Haruna M, Ito K, Yamada Y. 2013. Prevalence and antimicrobial susceptibility of foodborne bacteria in wild boars (*Sus scrofa*) and wild deer (*Cervus nippon*) in Japan. *Foodborne Pathogens Disease* 10: 985-991
226. Sasaki Y, Haruna M, Mori T, Kusukawa M, Murakami M, Tsujiyama Y, Ito K, Toyofuku H, Yamada Y. 2014. Quantitative estimation of *Campylobacter* cross-contamination in carcasses and chicken products at an abattoir. *Food Control* 43: 10-17
227. Sasaki Y, Haruna M, Murakami M, Hayashida M, Ito K, Noda M, Yamada Y. 2013. Prevalence of *Campylobacter* spp., *Salmonella* spp., *Listeria monocytogenes*, and Hepatitis E

virus in swine livers collected at an abattoir. *Jap J Infect Dis* 66: 161-164

228. Sasaki Y, Murakami M, Haruna M, Maruyama N, Mori T, Ito K, Yamada Y. 2013. Prevalence and characterization of foodborne pathogens in dairy cattle in the eastern part of Japan. *J Vet Med Sci* 75: 543-546
229. Scallan E, Hoekstra RM, Angulo FJ, Tauxe RV, Widdowson MA, Roy SL, Jones JL, Griffin PM. 2011. Foodborne illness acquired in the United States — major pathogens. *Emerg Infect Dis* 17: 7-15
230. Scanlon KA, Cagney C, Walsh D, McNulty D, Carroll A, McNamara EB, McDowell DA, Duffy G. 2013. Occurrence and characteristics of fastidious *Campylobacteraceae* species in porcine samples. *Int J Food Microbiol* 163: 6-13
231. Scanlon KA, Tiwari U, Cagney C, Walsh D, McDowell DA, Duffy G. 2015. Modelling the thermal inactivation of five Campylobacteraceae species. *Food Control* 47: 135-140
232. Scharff RL. 2012. Economic burden from health losses due to foodborne illness in the United States. *J Food Prot* 75: 123-131
233. Scheinberg J, Doores S, Cutter CN. 2013. A microbiological comparison of poultry products obtained from farmers' markets and supermarkets in Pennsylvania. *J Food Safety* 33: 259-264
234. Schiellerup P, Krogfelt KA, Locht H. 2008. A comparison of self-reported joint symptoms following infection with different enteric pathogens: effect of Hla-B27. *J Rheumatol* 35: 480-487
235. Schoeni JL, Wong ACL. 1994. Inhibition of *Campylobacter jejuni* colonization in chicks by defined competitive-exclusion bacteria. *Appl Environ Microbiol* 60: 1191-1197
236. Sears A, Baker MG, Wilson N, Marshall J, Muellner P, Campbell DM, Lake RJ, French NP. 2011. Marked campylobacteriosis decline after interventions aimed at poultry, New Zealand. *Emerg Infect Dis* 17: 1007-1015
237. Serraino A, Florio D, Giacometti F, Piva S, Mion D, Zanoni RG. 2013. Presence of *Campylobacter* and *Arcobacter* species in in-line milk filters of farms authorized to produce and sell raw milk and of a water buffalo dairy farm in Italy. *J Dairy Sci* 96: 2801-2807
238. Food Safety and Inspection Service. 2014. Quarterly progress report on *Salmonella* and *Campylobacter* testing of selected raw meat and poultry products: preliminary results, January 2014 to March 2014. http://www.fsis.usda.gov/wps/portal/fsis/topics/data-collection-and-reports/microbiology/quarterly-reports-salmonella. Accessed December 2014
239. Shane SM, Gifford DH, Yogasundram K. 1986. *Campylobacter jejuni* contamination of eggs. *Vet Res Commun* 10: 487-492
240. Shen Z, Luangtongkum T, Qiang Z, Jeon B, Wang L, Zhang Q. 2014. Identification of a novel membrane transporter mediating resistance to organic arsenic in *Campylobacter jejuni*. *Antimicrob Agents Chemother* 58: 2021-2029
241. Signorini ML, Zbrun MV, Romero-Scharpen A, Olivero C, Bongiovanni F, Soto LP, Frizzo LS, Rosmini MR. 2013. Quantitative risk assessment of human campylobacteriosis by consumption of salad cross-contaminated with thermophilic *Campylobacter* spp. from broiler meat in Argentina. *Prev Vet Med* 109: 37-46
242. Singh P, Kwon YM. 2013. Comparative analysis of *Campylobacter* populations within individual market-age broilers using fla gene typing method. *Poultry Sci* 92: 2135-2144
243. Smelt JPPM, Brul S. 2014. Thermal inactivation of microorganisms. *Crit Rev Food Sci Nutr* 54: 1371-1385
244. Smith KE, Stenzel SA, Bender JB, Wagstrom E, Soderlund D, Leano FT, Taylor CM, Belle-Isle PA, Richard D. 2004. Outbreaks of enteric infections caused by multiple pathogens associated with calves at a farm day camp. *Pediatr Infect Dis J* 23: 1098-1104
245. Sparks NHC. 2009. The role of the water supply system in the infection and control of *Campylobacter* in chicken. *Worlds Poultry Sci J* 65: 459-473
246. Stafford RJ, Schluter P, Kirk M, Wilson A, Unicomb L, Ashbolt R, Gregory J. 2007. A multi-centre prospective case-control study of *Campylobacter* infection in persons aged 5 years and older in Australia. *Epidemiol Infect* 135: 978-988
247. Steinmuller N, Demma L, Bender JB, Eidson M, Angulo FJ. 2006. Outbreaks of enteric disease associated with animal contact: not just a foodborne problem anymore. *Clin Infect Dis* 43: 1596-1602
248. Stephan R, Buhler K. 2002. Prevalence of *Campylobacter* spp., *Salmonella* spp. and *Listeria monocytogenes* in bulk-tank milk samples from north-east Switzerland. *Arch Lebensmittelhygiene* 53: 62-65
249. Strachan NJC, MacRae M, Thomson A, Rotariu O, Ogden ID, Forbes KJ. 2012. Source attribution, prevalence and enumeration of *Campylobacter* spp. from retail liver. *Int J Food Microbiol* 153: 234-236
250. Stuart TL, Sandhu J, Stirling R, Corder J, Ellis A, Misa P, Goh S, Wong B, Martiquet P, Hoang L, Galanis E. 2010. Campylobacteriosis outbreak associated with ingestion of mud during a mountain bike race. *Epidemiol Infect* 138: 1695-703
251. Sung J, Morales W, Kim G, Pokkunuri V, Weitsman S, Rooks E, Marsh Z, Barlow GM, Chang C, Pimentel M. 2013. Effect of repeated *Campylobacter jejuni* infection on gut flora and mucosal defense in a rat model of post infectious functional and microbial bowel changes. *Neurogastroenterol Motility* 25 DOI: 10.1111/nmo.12118
252. Swart AN, Mangen MJJ, Havelaar AH. 2013. Microbiological criteria as a decision tool for controlling *Campylobacter* in the broiler meat chain, National Institute for Public Health and the Environment (The Netherlands) http://www.rivm.nl/en/Documents_and_publications/Scientific/Reports/2013/juni/Microbiological_criteria_as_a_decision_tool_for_controlling_Campylobacter_in_the_broiler_meat_chain. Accessed March 2014
253. Tamborini AL, Casabona LM, Vinas MR, Asato V, Hoffer A, Farace MI, Lucero MC, Corso A, Pichel M. 2012. *Campylobacter* spp.: prevalence and pheno-genotypic characterization of isolates recovered from patients suffering from diarrhea and their pets in La Pampa province, Argentina. *Rev Argentina Microbiol* 44: 266-271
254. Taylor DN, Porter BW, Williams CA, Miller HG, Bopp CA, Blake PA. 1982. *Campylobacter* enteritis: a large outbreak traced to commercial raw milk. *West J Med* 137: 365-369
255. Teh AHT, M. LS, Dykes GD. 2014. Does *Campylobacter jejuni* form biofilms in food-related environments? *Appl Environ Microbiol* 80: 5154-5160
256. Terhune C, Sazi E, Kalishman N, Bobst J, Bonnlander B, et al. 1981. Raw-milk-associated illness — Oregon, California. *Morbid Mortal Weekly Rep* 30: 90-92
257. Tettmar RE, Thornton EJ. 1981. An outbreak of *Campylobacter* enteritis affecting an operational Royal-Air-Force unit. *Public Health* 95: 69-73
258. Thanissery R, Smith DP. 2014. Marinade with thyme and orange oils reduces *Salmonella* Enteritidis and *Campylobacter coli* on inoculated broiler breast fillets and whole wings. *Poultry Sci* 93: 1258-1262
259. Thomas MK, Murray R, Flockhart L, Pintar K, Pollari F, et al. 2013. Estimates of the burden of foodborne illness in Canada for 30 specified pathogens and unspecified agents, circa 2006. *Foodborne Pathog Dis* 10: 639-648
260. Torralbo A, Borge C, Allepuz A, Garcia-Bocanegra I, Sheppard SK, et al. 2014. Prevalence and risk factors of *Campylobacter* infection in broiler flocks from southern Spain. *Prev Vet Med* 114: 106-113
261. Townes JM. 2010. Reactive arthritis after enteric infections in the United States: the problem of definition. *Clin Infect Dis* 50: 247-254
262. Townes JM, Deodhar AA, Laine ES, Smith K, Krug HE, et al. 2008. Reactive arthritis following culture-confirmed infections with bacterial enteric pathogens in Minnesota and Oregon: a population-based study. *Ann Rheumatic Dis* 67: 1689-1696
263. Uaboi-Egbenni PO, Bessong PO, Samie A, Obi CL. 2012. Potentially pathogenic *Campylobacter* species among farm animals in rural areas of Limpopo province, South Africa: a

case study of chickens and cattles. *Afr J Microbiol Res* 6: 2835-2843
264. Uhlmann S, Galanis E, Takaro T, Mak S, Gustafson L, et al. 2009. Where's the pump? Associating sporadic enteric disease with drinking water using a geographic information system, in British Columbia, Canada, 1996–2005. *J Water Health* 7: 692-698
265. Unicomb LE, Dalton CB, Gilbert GL, Becker NG, Patel MS. 2008. Age-specific risk factors for sporadic *Campylobacter* infection in regional Australia. *Foodborne Pathogens Dis* 5: 79-85
266. Usui M, Sakemi Y, Uchida I, Tamura Y. 2014. Effects of fluoroquinolone treatment and group housing of pigs on the selection and spread of fluoroquinolone-resistant *Campylobacter*. *Vet Microbiol* 170: 438-441
267. Van Houten C, Musgrave K, Weidenbach K, Murphy T, Manley W, et al. 2011. *Campylobacter jejuni* infections associated with sheep castration — Wyoming, 2011. *Morbid Mortal Weekly Rep* 60: 1654
268. Venkitanarayanan K, Kollanoor-Johny A, Darre MJ, Donoghue AM, Donoghue DJ. 2013. Use of plant-derived antimicrobials for improving the safety of poultry products. *Poultry Sci* 92: 493-501
269. Verma AK, Kumar A, Singh SK, Rahal A, Iftekhar A, I., et al. 2014. Prevalence and resistance to antimicrobial agents of *Campylobacter* sp. isolated from dogs in India. *J Biol Sci* 14: 142-148
270. Veterinarians NAoSPH. 2013. Compendium of measures to prevent disease associated with animals in public settings, 2013. *J Am Vet Med Assoc* 243: 1270-1288
271. Vipham JL, Brashears MM, Loneragan GH, Echeverry A, Brooks JC, et al. 2012. *Salmonella* and *Campylobacter* baseline in retail ground beef and whole-muscle cuts purchased during 2010 in the United States. *J Food Prot* 75: 2110-2115
272. Vogt RL, Sours HE, Barrett T, Feldman RA, Dickinson RJ, Witherell L. 1982. *Campylobacter* enteritis associated with contaminated water. *Ann Intern Med* 96: 292-296
273. Von Altrock A, Hamedy A, Merle R, Waldmann KH. 2013. *Campylobacter* spp. — prevalence on pig livers and antimicrobial susceptibility. *Prev Vet Medicine* 109: 152-157
274. Wagenaar JA, French NP, Havelaar AH. 2013. Preventing *Campylobacter* at the source: Why is it so difficult? *Clin Infect Dis* 57: 1600-1606
275. Waldenström J, Axelsson-Olsson D, Olsen B, Hasselquist D, Griekspoor P, et al. 2010. *Campylobacter jejuni* colonization in wild birds: results from an infection experiment. *PLoS ONE* 5: e9082
276. Wang CM, Shia WY, Jhou YJ, Shyu CL. 2013. Occurrence and molecular characterization of reptilian *Campylobacter fetus* strains isolated in Taiwan. *Vet Microbiol* 164: 67-76
277. Weber R, Auerbach M, Jung A, Glunder G. 2014. *Campylobacter* infections in four poultry species in respect of frequency, onset of infection and seasonality. *Berliner Munchener Tierarztliche Wochenschr* 127: 257-266
278. Wedderkopp A, Madsen AM, Jørgensen PH. 2003. Incidence of *Campylobacter* species in hobby birds. *Vet Rec* 152: 179-180
279. Weis AM, Miller WA, Byrne BA, Chouicha N, Boyce WM, Townsend AK. 2014. Prevalence and pathogenic potential of *Campylobacter* isolates from free-living, human-commensal American crows. *Appl Environ Microbiol* 80: 1639-1644
280. Wells JE, Kalchayanand N, Berry ED, Oliver WT. 2013. Effects of antimicrobials fed as dietary growth promoters on faecal shedding of *Campylobacter*, *Salmonella* and Shiga-toxin producing *Escherichia coli* in swine. *J Appl Microbiol* 114: 318-328
281. Wijnands LM, Delfgou-van Asch EHM, Beerepoot-Mensink ME, van der Meij-Florijn A, Fitz-James I, van Leusden FM, Pielaat A. 2014. Prevalence and concentration of bacterial pathogens in raw produce and minimally processed packaged salads produced in and for The Netherlands. *J Food Prot* 77: 388-394
282. World Health Organization. 2013. Global view of campylobacteriosis. http://www.who.int/foodsafety/publications/campylobacteriosis/en/ Accessed: June, 2013
283. Wu Z, Sippy R, Sahin O, Plummer P, Vidal A, Newell D, Zhang Q. 2014. Genetic diversity and antimicrobial susceptibility of *Campylobacter jejuni* isolates associated with sheep abortion in the United States and Great Britain. *J Clin Microbiol* 52: 1853-1861
284. Yanagisawa S. 1980. Large outbreak of *Campylobacter* enteritis among school-children. *Lancet* 2: 153
285. Yano S, Amano E, Katou A, Taneda I, TsuTtsui T, Murase T. 2014. Intestinal carriage and excretion of *Campylobacter jejuni* in chickens exposed at different ages. *J Food Prot* 77: 1184-7
286. Yeh HY, Hiett KL, Line JE, Seal BS. 2014. Characterization and reactivity of broiler chicken sera to selected recombinant *Campylobacter jejuni* chemotactic proteins. *Arch Microbiol* 196: 375-83
287. Yoder JS, Hlavsa MC, Craun GF, Hill V, Roberts V, Yu PA, Hicks LA, Alexander NT, Calderon RL, Roy SL, et al. 2008. Surveillance for waterborne disease and outbreaks associated with recreational water use and other aquatic facility-associated health events — United States, 2005–2006. *Morbid Mortal Weekly Rep* 57: 1-38
288. Yu JH, Kim NY, Cho NG, Kim JH, Kang YA, Lee HG. 2010. Epidemiology of *Campylobacter jejuni* outbreak in a middle school in Incheon, Korea. *J Korean Med Science* 25: 1595-1600
289. Zautner AE, Johann C, Strubel A, Busse C, Tareen AM, Masanta WO, Lugert R, Schmidt-Ott R, Groß. 2014. Seroprevalence of campylobacteriosis and relevant post-infectious sequelae. *Eur J Clin Microbiol Infect Dis* 33: 1019-1027
290. Zbrun MV, Romero-Scharpen A, Olivero C, Rossler E, Soto LP, Rosmini MR, Sequeira GJ, Signorini ML, Frizzo LS. 2013. Occurrence of thermotolerant *Campylobacter* spp. at different stages of the poultry meat supply chain in Argentina. *New Zealand Vet J* 61: 337-343
291. Zendehbad B, Arian AA, Alipour A. 2013. Identification and antimicrobial resistance of *Campylobacter* species isolated from poultry meat in Khorasan province, Iran. *Food Control* 32: 724-727
292. Zhang M, Li Q, He L, Meng F, Gu Y, Zheng M, Gong Y, Wang P, Ruan F, Zhou L, et al. 2010. Association study between an outbreak of Guillain-Barré syndrome in Jilin, China, and preceding *Campylobacter jejuni* infection. *Foodborne Pathogens Dis* 7: 913-919
293. Zhao T, Doyle MP, Berg DE. 2000. Fate of *Campylobacter jejuni* in butter. *J Food Prot* 63: 120-122
294. Zweifel C, Scheu KD, Keel M, Renggli F, Stephan R. 2008. Occurrence and genotypes of *Campylobacter* in broiler flocks, other farm animals, and the environment during several rearing periods on selected poultry farms. *Int J Food Microbiol* 125: 182-187

Appendix: Campylobacter Outbreaks*

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
1938	*Vibrio jejuni*	US: IL	357	151	Milk, raw	(*107*)
1978	*C. jejuni*	US: CO	3		Milk, raw	(*15*)
1978	*C. jejuni*	US: VT	3,000		Water	(*169*)
1978	*C. jejuni*	US: CO	7		Animal contact: sick dog	(*17*)
1978	*C.* spp.	UK	100		Milk, raw	(*141*)
1978	*C.* spp.	UK	64		Milk, raw	(*141*)
1978	*C.* spp.	UK	16		Milk, raw	(*141*)
1978	*C. jejuni*	Netherlands	89	24	Chicken, undercooked	(*27*)
1979	*C. jejuni*	US: IA	3		Chicken, undercooked	(*147*)
1979	*C. jejuni*	US: IA	2		Chicken, undercooked	(*147*)
1979	*C. jejuni*	US: NM	41		Milk, raw	(*18*)
1979	*C. jejuni*	US: CO	8		Person-to-person	(*18*)
1979	*C. jejuni*	US: MI	4		Person-to-person	(*19*)
1979	*C. jejuni*	US: MI	4		Person-to-person	(*19*)
1979	*C. jejuni*	Scotland	205		Milk, raw	(*135*)
1979	*C. jejuni*	UK	3,500		Milk, raw	(*95; 141)*
1979	*C. jejuni*	UK	75		Milk, raw	(*141*)
1979	*C.* spp.	UK	13		Milk, raw	(*141*)
1979	*C.* spp.	UK	4		Milk, raw	(*141*)
1979	*C. jejuni*	UK	14		Milk, raw	(*141*)
1979	*C. jejuni*	Japan	37		Food, unknown (school)	(*89*)
1980	*C. jejuni*	Sweden	2,000	7	Water, drinking, unchlorinated	(*117*)
1980	*C. jejuni*	Sweden	37		Animal contact: poultry (abattoir)	(*32*)
1980	*C. jejuni*	Canada	27		Milk, raw	(*29; 114)*
1980	*C.* spp.	Japan	800		Pork, vinagered	(*174*)
1980	*C.* spp.	UK	86		Milk, raw	(*164*)
1980	*C. jejuni*	UK	75		Milk, raw	(*141*)
1980	*C. jejuni*	UK	40		Milk, raw	(*141*)
1980	*C.* spp.	UK	8		Milk, raw	(*141*)
1980	*C. jejuni*	UK	21		Chicken, undercooked	(*150*)
1980	*C. jejuni*	US: CT	1,300		Water	(*141*)
1980	*C. jejuni*	US: WY	21		Water	(*18*)
1980	*C. jejuni*	US: CT	41		Cake icing; salad	(*16; 18)*
1980	*C. jejuni*	US: MN	9		Chicken	(*43*)
1980	*C. jejuni*	US: CA	11		Turkey, processed	(*18*)
1979–1981	*C. jejuni*	US: CA	10		Liver, raw, calves	(*51*)
1980–1981	*C. jejuni*	US: OR	91		Milk, raw	(*163*)

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu Food Research Institute, University of Wisconsin–Madison
Funded in part by the North American Meat Institute February 2015

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
1981	*C. jejuni*	UK	46		Milk, raw	(*173*)
1981	*C. jejuni*	UK	22		Milk, raw	(*173*)
1981	*C. jejuni*	Sweden	66		Chicken	(*23*)
1981	*C. jejuni*	Netherlands	9		Person-to-person	(*166*)
1981	*C. jejuni*	US: AZ	208	2	Milk, raw	(*162*)
1981	*C. jejuni*	US: MN	25		Milk, raw	(*99*)
1981	*C. jejuni*	US: CO	2		Milk, raw	(*18*)
1981	*C. jejuni*	US: KS	60	1	Milk, raw	(*100*)
1981	*C. jejuni*	US: GA	50		Milk, raw	(*136*)
1981	*C. jejuni*	US: IL	78		Water, drinking	(*161*)
1981	*C. jejuni*	US: IL	7	2	Salad	(*52*)
1981	*C. jejuni*	US: NY	3		Food, restaurant	(*43*)
1981	*C. jejuni*	US: NY	19		Beef, egg	(*43*)
1981	*C. jejuni*	US: ME	3		Milk, raw	(*43*)
1981	*C. jejuni*	US: AZ	14		Milk, raw	(*43*)
1981	*C. jejuni*	US: ME	14		Milk, raw	(*43*)
1981	*C. jejuni*	US: NY	10		Food, fraternity	(*43*)
1981	*C. jejuni*	US: GA	18		Milk, raw	(*136*)
1981	*C. jejuni*	UK	258		Water, drinking, unchlorinated	(*131*)
1982	*C.* spp.	UK	145		Milk, raw	(*8*)
1982	*C.* spp.	UK	42		Milk, raw	(*8*)
1982	*C.* spp.	UK	~400		Milk, raw	(*8*)
1982	*C. jejuni*	US: MD	46		Milk, raw	(*43*)
1982	*C. jejuni*	US: GA	6		Chicken	(*43*)
1982	*C. jejuni*	US: MI	32		Milk, raw	(*43*)
1982	*C. jejuni*	US: ME	32		Milk, raw	(*43*)
1982	*C. jejuni*	US: MN	26		Eggs	(*43*)
1982	*C. jejuni*	US: VT	15		Milk, raw	(*43*)
1982	*C. jejuni*	US: VT	4		Milk, raw	(*43*)
1982	*C. jejuni*	US: WA	2		Food, Chinese	(*43*)
1982	*C. jejuni*	Israel	22		Food handler	(*34*)
1982	*C. jejuni*	Israel	150		Water, drinking	(*143*)
1982	*C.* spp.	New Zealand	51		Milk, raw	(*24*)
1982	*C. jejuni*	US: WI	15		Milk, raw	(*98*)
1982	*C. jejuni*	US: CO	11	0	Chicken, undercooked	(*88*)
1983	*C. jejuni*	UK	75		Milk, raw	(*85*)
1983	*C. jejuni*	US: FL	865	4	Water, drinking	(*146*)
1983	*C. jejuni*	US: PA	31	0	Milk, raw	(*20*)
1983	*C. jejuni*	US: WA	6		Milk, goat, raw	(*76*)
1983	*C. jejuni*	US: PA	26	1	Milk, raw	(*20*)
1983	*C. jejuni*	US: VT	13		Milk, raw	(*83*)
1983	*C.* spp.	New Zealand	38		Milk, raw	*(24)*
1983	*C. jejuni*	Australia	7		Chicken	(*145*)
1984	*C. jejuni*	US: CA	12		Milk, raw	(*137*)
1984	*C. jejuni*	Norway	300		Water, drinking	(*35*)
1984	*C. coli*	UK	3	0	Milk, goat, raw	(*86*)
1984	*C. jejuni*	France	11	11	Nosocomial	(*54*)
1984–1986	*C. jejuni*	UK	19		Chicken	(*133*)
1985	*C. laridis*	Canada	162		Water, drinking	(*26*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
1985	*C. jejuni*	Canada	241		Water, drinking	(*119*)
1985	*C. jejuni*	US: AR	19		Water, drinking	(*156*)
1985	*C. jejuni*	US: WI	150		Water, drinking	(*156*)
1985	*C. jejuni*	US: CA	25		Milk, raw	(*11*)
1985	*C. jejuni*	US: WI	16	2	Cantaloupe	(*21*)
1986	*C. jejuni*	Israel	7		Person-to-person	(*78*)
1986	*C.* spp.	New Zealand	19		Water, drinking	(*25*)
1986	*C.* spp.	Canada	50		Water, drinking	(*82*)
1986	*C. jejuni*	US: VT	35		Milk, raw	(*12*)
1987	*C. jejuni*	Finland	79		Water, drinking	(*3*)
1987	*C. fetus*	Japan	7		Nosocomial	(*124*)
1987	*C. jejuni*	Canada	18		Water, drinking	(*4*)
1988	*C. jejuni; C. coli*	Norway	330		Water, drinking	(*116*)
1988	*C. jejuni*	Norway	680		Water, drinking	(*115*)
1990	*C. jejuni*	New Zealand	44		Water, drinking	(*157*)
1990	*C.* spp.	US: WA	13		Milk, raw	*(189)*
1990	*C. jejuni*	US: TX	42		Milk, raw	*(189)*
1991	*C. jejuni*	UK	11		Milk, contaminated by birds	(*140*)
1991	*C. jejuni*	US: NY	20		Meats, cold tray	*(188)*
1991	*C. jejuni*	US: PA	10		Chicken, fruit	*(188)*
1991	*C. jejuni*	US: WA	3		Milk, goat, raw	*(188)*
1991–1992	*C. upsaliensis*	Belgium	44		Person-to-person	(*53*)
1992	*C.* spp.	UK	72		Milk, raw	(*123*)
1992	*C. jejuni*	UK	110		Milk, raw	(*41*)
1992	*C.* spp.	US: ME	11		Milk, raw	*(187)*
1992	*C. jejuni*	US: IN	34		Pasta salad, potatoes	*(187)*
1992	*C. jejuni*	US: MN	50		Milk, raw	*(187)*
1992	*C. jejuni*	US: NY	23		Milk	*(187)*
1993	*C.* spp.	UK	8	0	Water, drinking	(*45*)
1993	*C.* spp.; *Cryptosporidium*	UK	43	2	Water, drinking (lamb carcasses)	(*36*)
1993	*C. coli*	UK	36	0	Water, drinking	(*45*)
1993	*C. jejuni*	US: NY	172		Water, drinking	(*101*)
1993	*C. jejuni*	US: MN	32		Water, drinking	(*101*)
1993	*C. jejuni*	US: MN	48		Melon, strawberries	*(186)*
1994	*C. jejuni*	Canada	7		Animal exposure: turkeys	(*38*)
1994	*C. jejuni*	US: MN	19		Water, drinking	(*101*)
1994	*C. jejuni*	US: MN	62		Fruit salad	*(185)*
1994	*C. jejuni*	UK	23		Milk, raw	(*40*)
1994	*C. jejuni*	UK	53	0	Water, drinking	(*45*)
1994	*C.* spp.	UK	8	0	Water, drinking	(*45*)
1994	*C. jejuni*	UK	22	0	Water, drinking	(*45*)
1994	*C.* spp.	UK	12		Chicken, undercooked	(*125*)
1994	*C.* spp.	UK	41		Water, drinking	(*151*)
1994	*C.* spp.	Sweden	2,500		Water, drinking	(*7*)
1995	*C.* spp.	Sweden	3,000		Water, drinking	(*7*)
1995	*C. coli*	Belgium	24		Salad, mixed, with ham & cheese	(*144*)
1995	*C.* spp.; *E. coli*	UK	633		Water, drinking	(*94*)
1995	*C.* spp.	UK	12		Milk, bird-pecked bottles	(*159*)
1995	*C.* spp.	US: OH	7		Water: bagged ice	(*108*)
1995	*C. jejuni*	US: WI	79		Tuna salad	(*142*)
1995	*C.* spp.	US: WI	11		Beef barbecue	*(184)*

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
1995	*C. jejuni*	US: FL	17		Chicken, cole slaw	*(184)*
1995	*C. jejuni*	US: NY	9		Pork	*(184)*
1996	*C. jejuni*	US: OK	14	2	Lettuce, contaminated by raw chicken	(*56*)
1996	*C. jejuni*	US: NY	29		Milk	*(183)*
1996	*C. jejuni*	US: NY	70		Salad	*(183)*
1997	*C.* spp.	Australia	23		Water, drinking	(*118*)
1997	*C. jejuni*	Northern Ireland	12		Salad, lettuce & tomato	(*122*)
1997	*C.* spp.	US: CT	17	3	Sweet potatoes, other foods (1 death)	(*172*) *(182)*
1997	*C.* spp.	US: FL	4		Shellfish	*(182)*
1997	*C. jejuni*	UK	12		Chicken, undercooked	(*39*)
1997	*C. jejuni*	UK	52		Chicken and other foods	(*50*)
1998	*C. jejuni*	Austria	38		Milk, raw	(*106*)
1998	*C. jejuni*	Finland	~2,700	7	Water, drinking, unchlorinated	(*103*)
1998	*C. jejuni*; *C. coli*	Hungary	34		Milk, raw	(*96*)
1998	*C. jejuni*; *Shigella*; norovirus	Switzerland	1,607		Water, drinking	(*112*)
1998	*C.* spp.	US: FL	16	1	Chicken	(*31*)
1998	*C. jejuni*	US: KS	129	2	Gravy, pineapple; food handler	(*129*)
1998	*C. jejuni*	US: MN	300	0	Lettuce	(*31*)
1998	*C. jejuni*	US: SD	6	1	Milk, raw	(*31*)
1998	*C.* spp.	US: NY	3		Milk, raw	(*31*)
1998	*C. jejuni*	US: WA	2	0	Oysters	(*31*)
1998	*C. jejuni*	US: FL	3		Fish, salmon and tuna, raw	(*31*)
1998	*C.* spp.	US: FL	3	1	Chicken sandwich	(*31*)
1998	*C. jejuni*	US: WI	16	0	Salad, taco or nacho	(*31*)
1998	*C. jejuni*; *S. enterica*	US: OR	22	1	Turkey	(*31*)
1999	*C. jejuni*	US: CA	13	1	Chicken	(*31*)
1999	*C.* spp.	US: FL	2	0	Food, ethnic	(*31*)
1999	*C. jejuni*	US: WA	2		Milk, raw	(*31*)
1999	*C. jejuni*	US: MD	34	0	Beef	(*31*)
1999	*C.* jejuni; E. *coli*	US: NY	781	71	Water, drinking	(*105; 126)*
1999	*C. jejuni*	US: FL	6		Water, swimming pool	(*105*)
2000	*C. jejuni*	US: ID	15		Water, drinking	(*105*)
2000	*C. jejuni*	US: UT	102		Water, irrigation, used for drinking	(*105*)
2000	*C. coli*; rotavirus; norovirus	France	2,600		Water, drinking	(*46*)
2000	*C. jejuni*	UK	281		Water, drinking	(*139*)
2000	*C. jejuni*	Finland	~900		Water, drinking, unchlorinated (Nokia)	(*102*)
2000	*C. jejuni*; *E. coli* O157:H7	Canada (Walkerton)	2,300		Water, drinking	(*33*)
2000	*C.* spp.	UK	14	4	Water, drinking	(*9*)
2000	*C. jejuni*	US: multistate	18	0	Cheese, raw milk	(*31*)
2000	*C. jejuni*	US: CT	13	1	Lettuce-based salads	(*31*)
2000	*C. jejuni*	US: PA	3	1	Milk, pasteurized	(*31*)
2000	*C. jejuni*	US: WI	19	0	Milk, raw	(*31*)
2000	*C.* spp.	US: TX	2		Milk, raw	(*31*)
2000	*C. jejuni*	US: OK	11	1	Milk, raw	(*31*)
2000	*C. jejuni*	US: OK	21	2	Milk, raw	(*31*)
2000	*C.* spp.	US: MN	8	1	Milk, raw	(*31*)
2000	*C. jejuni*	US: ID	42	1	Milk, raw	(*31*)
2000	*C. jejuni*	US: NY	39		Milk, whole, raw	(*31*)
2000	*C. jejuni*	US: ID	4	0	Milk, whole, raw	(*31*)
2000	*C. jejuni*	US: WY	8		Animal contact: pheasants	(*79*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
1999–2001	*C. jejuni*	Canada	11		Person-to-person	(*49*)
2000–2001	*C. jejuni*; *E. coli*; *Cryptosporidium*; *Salmonella*	US: MN	84		Animal contact: calves	(*155*)
2001	*C. jejuni*	Australia	3		Chicken	(*58*)
2001	*C.* spp.	Australia	2		Duck liver	(*60*)
2001	*C.* spp.	Australia	6		Milk, raw	(*60*)
2001	*C.* spp.	Australia	48		Salad	(*59*)
2001	*C.* spp.	Australia	49		Food, unknown	(*59*)
2001	*C. jejuni*	Australia	10		Food, restaurant	(*138*)
2001	*C. jejuni*	Germany	5		Chicken	(*5*)
2001	*C. jejuni*; *S. enterica*	US: WI	80		Beef, steak	(*31*)
2001	*C. jejuni*	US: CA	3	0	Chicken	(*31*)
2001	*C. jejuni*	US: WY	4	0	Chicken; dumplings	(*31*)
2001	*C.* spp.	US: OH	3	0	Chicken, other; lettuce-based salads	(*31*)
2001	*C. jejuni*	US: MD	14		Chicken	(*31*)
2001	*C. jejuni*	US: AZ	62	4	Chicken and beef enchilada	(*31*)
2001	*C.* spp.	US: FL	2	1	Food, ethnic buffet	(*31*)
2001	*C. jejuni*	US: MD	14		Fruit salad	(*31*)
2001	*C. jejuni*; *S. aureus*	US: WI	20	3	Meat	(*31*)
2001	*C. jejuni*	US: NY	16		Potato salad	(*31*)
2001	*C. jejuni*	US: NE	24	1	Potato salad	(*31*)
2001	*C. jejuni*	US: WA	2	0	Quail	(*31*)
2001	*C.* spp.	US: NY	3		Beef sandwich; chicken Parmesan sandwich	(*31*)
2001	*C. jejuni*	US: WI	75	0	Milk, whole, raw	(*75*)
2001	*C. jejuni*	US: MN	4	0	Milk, whole, raw	(*31*)
2001	*C. jejuni*; *Y. enterocolitica*	US: AK	12		Water, drinking	(*14*)
2001	*C. jejuni*	US: WI	13		Water, drinking	(*14*)
2002	*C. jejuni*; *Entamoeba*; *Giardia*	US: NY	27		Water, drinking	(*109*)
2002	*C. jejuni*	Australia	24		Chicken	(*61*)
2002	*C. jejuni*	Finland	6	1	Milk, raw	(*148*)
2002	*C.* spp.	US: MN	3	1	Animal contact: chickens, pigs	(*158*)
2002	*C.* spp.	US: MN	9	0	Animal contact: turkeys	(*158*)
2002	*C. jejuni*	US: CA	3	0	Pork burrito	(*31*)
2002	*C. jejuni*	US: CA	3	1	Burrito; salsa	(*31*)
2002	*C. jejuni*	US: FL	8		Chicken, BBQ	(*31*)
2002	*C. jejuni*	US: FL	4	1	Chicken, buffalo wings	(*31*)
2002	*C.* spp.	US: MO	18	0	Chicken; mashed potato/gravy; vegetables	(*31*)
2002	*C. coli*	US: AR	7	0	Salad, green	(*31*)
2002	*C. jejuni*	US: WA	136	1	Salads, green, pasta, tuna	(*31*)
2002	*C. jejuni*	US: CA	50	5	Guacamole	(*31*)
2002	*C.* spp.	US: CA	5	0	Liver	(*31*)
2002	*C. jejuni*	US: KS	46	1	Milk, raw	(*31*)
2002	*C.* spp.	US: CA	12	0	Milk, raw	(*31*)
2002	*C. jejuni*	US: WA	2	0	Pizza, meat and vegetable	(*31*)
2002	*C. jejuni*	US: VA	20		Potato salad	(*31*)
2002	*C.* spp.; *S. enterica*	US: CA	6	0	Salsa	(*31*)
2002	*C.* spp.	US: WA	2	0	Beef sandwich	(*31*)
2002	*C.* spp.	US: MN	4	0	Salads	(*31*)
2002	*C. jejuni*	US: WA	2	0	Milk, whole, raw	(*31*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
2002	*C. jejuni*	US: UT	13	0	Milk, whole, raw	(*134*)
2003	*C.* spp.	Australia	2	1	Caesar salad	(*62*)
2003	*C.* spp.	Australia	19	0	Chicken	(*62*)
2003	*C.* spp.	Australia	13	0	Milk, raw	(*62*)
2003	*C. jejuni*; *S. enterica*	US: MN	15	2	Beef, raw	(*31*)
2003	*C. jejuni*	US: CA	4	0	Ceviche	(*31*)
2003	*C. jejuni*	US: WI	5	0	Chicken, baked	(*31*)
2003	*C.* spp.	US: WA	3	0	Chicken, fried	(*31*)
2003	*C. jejuni*	US: WA	2	0	Chicken, other	(*31*)
2003	*C. jejuni*	US: CA	5	0	Chicken	(*31*)
2003	*C.* spp.	US: CA	5	0	Chicken	(*31*)
2003	*C. fetus*	US: WA	9	1	Cheese, raw	(*31*)
2003	*C. jejuni*	US: OK	7	0	Ice cream, homemade	(*31*)
2003	*C. jejuni*	US: WI	3	0	Nachos	(*31*)
2003	*C. jejuni*	US: VT	18	0	Cheese, raw milk	(*31*)
2003	*C. jejuni*	US: WI	2	0	Milk, raw	(*31*)
2003	*C. jejuni*	US: MI	6	0	Milk, raw	(*31*)
2003	*C. jejuni*; *E. coli*	US: WA	3	0	Milk, raw	(*31*)
2003	*C.* spp.	US: CA	11	0	Cheese: queso fresco, raw	(*31*)
2003	*C.* spp.	US: OH	2	0	Soup; poultry/egg	(*31*)
2003	*C.* spp.	US: multistate	87		Water, tap	(*31*)
2003	*C.* spp.	US: WI	17	0	Turkey, roasted	(*31*)
2003	*C. jejuni*; *Cryptosporidium*	France	200		Water, drinking	(*10*)
2003	*C. jejuni*	Spain	81		Custard (contaminated by chicken)	(*93*)
2003	*C. jejuni*; *Shigella*	US: OH	57		Water, drinking	(*109*)
2003	*C.* spp.	US: WA	110		Water, drinking	(*109*)
2004	*C. jejuni*	US: OH	82		Water, drinking	(*109*)
2004	*C.* spp.	US: OH	1,450		Water, drinking	(*109*)
2004	*C. jejuni*	US: VA	34		Water, drinking	(*109*)
2004	*C.* spp.	UK	36		Water, drinking	(77)
2004	*C. jejuni*; norovirus; *Giardia*; *Salmonella*	US: OH	1,450	21	Water, drinking, sewage contamination	(*128*)
2004	*C.* spp.	Australia	21	1	Chicken	(*63*)
2004	*C.* spp.	Australia	2	0	Chicken	(*63*)
2004	*C.* spp.	Australia	4	1	Food, unknown	(*63*)
2004	*C.* spp.	Australia	24	2	Meat, barbecue	(*63*)
2004	*C.* spp.	Australia	7	0	Water	(*63*)
2004	*C. jejuni*	Australia	3		Sausage, pre-cooked	(*55*)
2004	*C. jejuni*	US: CO	2	0	Chicken, grilled	(*31*)
2004	*C. jejuni*	US: TX	9	0	Salad, green	(*31*)
2004	*C.* spp.	US: OH	5	1	Ice cream, homemade	(*31*)
2004	*C. jejuni*	US: CA	5	0	Liver	(*31*)
2004	*C. jejuni*; norovirus	US: MN	29	0	Cake/cookie dough, raw	(*31*)
2004	*C. jejuni*	US: FL	2		Salad bar	(*31*)
2004	*C.* spp.	US: OH	13	0	Tomato	(*31*)
2004	*C. jejuni*	US: CA	2		Turkey	(*31*)
2004	*C. jejuni*	US: IA	32	0	Milk, whole, raw	(*31*)
2004	*C.* spp.	US: WY	6	1	Milk, whole, raw	(*31*)
2005	*C. jejuni*	Japan	36		Chicken	(*175*)
2005	*C. jejuni*	Scotland	86		Chicken liver pâté	(*44*)
2005	*C. jejuni*	Denmark	79	1	Chicken	(*113*)
2005	*C.* spp.	Australia	11	1	Chicken	(*64*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
2005	*C.* spp.	Australia	4	0	Chicken	(*64*)
2005	*C. jejuni*	Australia	35		Foods, multiple	(*120*)
2005	*C.* spp.	Australia	11	1	Chicken	(*13*)
2005	*C. jejuni*	US: CO	200	1	Milk, 1%, pasteurized	(*31*)
2005	*C. jejuni*	US: CO	14	0	Beans, baked; potato salad	(*31*)
2005	*C. jejuni*	US: MD	4	0	Salad, Caesar	(*31*)
2005	*C. jejuni*	US: OK	28	1	Beef and chicken fajita; onions; peppers	(*31*)
2005	*C. jejuni*	US: OK	11	3	Milk, goat and cow, raw	(*31*)
2005	*C. jejuni*	US: WI	13	2	Chicken liver	(*31*)
2005	*C.* spp.	US: WA	9	0	Chicken liver	(*31*)
2005	*B. cereus*; *C. jejuni*	US: CO	8	0	Noodles; quail	(*31*)
2005	*C. jejuni*	US: WY	3	0	Milk, raw	(*31*)
2005	*C. jejuni*	US: AK	18		Peas, green	(*47*)
2005	*C. jejuni*	US: WA	2	0	Sandwich, gyro	(*31*)
2005	*C.* spp.	US: CO	2	0	Dip, vegetable	(*31*)
2005	*C. jejuni*	US: KS	4	0	Milk, whole, raw	(*31*)
2005	*C. jejuni*	US: IA	33	0	Milk, whole, raw	(*31*)
2005	*C. jejuni*	US: WY	11	2	Milk, whole, raw	(*31*)
2005	*C. jejuni*	US: AZ	13	1	Milk, whole, raw	(*31*)
2005	*C. jejuni*	US: CO	5	0	Milk, whole, raw	(*31*)
2005	*C. jejuni*	US: UT	11	0	Milk, whole, raw	(*31*)
2005	*C. jejuni*	US: CO	22	0	Milk, whole, raw	(*31*)
2005	*C. jejuni*; *E. coli*	US: OR	60		Water, drinking	(*177*)
2005	*C. jejuni*	US: WY	6		Water, kiddie pool	(*176*)
2006	*C.* spp.	US: IN	32		Water, drinking	(*177*)
2006	*C. jejuni*	Australia	3	3	Chicken, undercooked	(*65*)
2006	*C. jejuni*	Australia	46	0	Water, drinking	(*65*)
2006	*C.* spp.	Australia	5	0	Chicken	(*65*)
2006	*C.* spp.	Australia	13	1	Unknown food	(*65*)
2006	*C. jejuni*	Japan	71		Water, tap, unchlorinated	(*1*)
2006	*C.* spp.	UK	48	2	Chicken liver pâté	(*127*)
2006	*C. jejuni*	Italy	5	5	Milk, raw	(*6*)
2006	*C. jejuni*	US: WY	141		Water, drinking, unchlorinated	(*167*)
2006	*C. jejuni*	US: WI	23	0	Beef; ham	(*31*)
2006	*C.* spp.	US: OH	13	2	Chicken, grilled; sausage, bratwurst	(*31*)
2006	*C.* spp.	US: CA	10	2	Chicken, pork, soy sauce	(*31*)
2006	*C. jejuni*	US: WA	10		Food, ethnic style	(*31*)
2006	*C. jejuni*	US: WI	58	2	Cheese, raw milk	(*31*)
2006	*C. jejuni*	US: CA	1,644	7	Milk, pasteurized	(*92*)
2006	*C. jejuni*	US: CO	3	0	Oysters, raw	(*31*)
2006	*C. jejuni*	US: VA	9	0	Milk, raw	(*31*)
2006	*C. jejuni*; *S. enterica*	US: WI	2	2	Turkey, baked	(*31*)
2006	*C. jejuni*	US: VA	15	1	Watermelon	(*31*)
2006	*C. jejuni*	US: IL	18	0	Milk, whole, raw	(*31*)
2006	*C.* spp.	US: OH	3	1	Milk, whole, raw	(*31*)
2006	*C.* spp.	US: NY	2	0	Milk, whole, raw	(*31*)
2006	*C.* spp.	US: CO	5	4	Milk, whole, raw	(*31*)
2007	*C.* spp.	Australia	2	1	Meat	(*66*)
2007	*C.* spp.	Scotland	52		Chicken liver pâté	(*153*)
2007	*C. jejuni*	Canada	225		Mud, ingestion of	(*160*)
2007	*C.* spp.; other enteric pathogens	Finland	8,453		Water, drinking; sewage contamination	(*104*)
2007	*C.* spp.	Norway	105		Water, drinking (est. total cases 1500)	(*91*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
2007	*C. jejuni*; *S. enterica*	US: WI	8	3	Beef	(*31*)
2007	*C. jejuni*	US: UT	62	4	Butter; goat milk and cheese, raw; milk, whole, raw	(*31*)
2007	*C.* spp.	US: CA	3	0	Candy, tamarindo	(*31*)
2007	*C. jejuni*	US: KS	16	0	Cheese, cheddar, raw; milk, raw	(*31*)
2007	*C. jejuni*	US: WA	3	1	Chicken	(*31*)
2007	*C. jejuni*	US: MI	11	0	Chicken	(*31*)
2007	*C. jejuni*	US: CO	26	4	Chili; ground beef, cheeseburger	(*31*)
2007	*C.* spp.	US: PA	3	0	Milk, ice cream, homemade	(*31*)
2007	*C. jejuni*	US: NY	2	0	Duck liver	(*31*)
2007	*C. jejuni*	US: KS	68	2	Cheese, soft, raw milk	(*31; 84)*
2007	*C. jejuni*	US: CO	4	1	Cheese	(*31*)
2007	*C. jejuni*	US: NH	13	2	Potato salad	(*31*)
2007	*C. jejuni*; *S. enterica*	US: SC	11	4	Milk, raw	(*31*)
2007	*C. jejuni*	US: GA	8	0	Milk, raw	(*31*)
2007	*C. jejuni*	US: WA	18	0	Milk, raw	(*31*)
2007	*C.* spp.	US: NY	2	1	Milk, raw	(*31*)
2007	*C. jejuni*	US: PA	4	0	Milk, raw	(*31*)
2007	*C. jejuni*	US: CA	11	0	Milk, raw	(*31*)
2007	*C.* spp.	US: NM	48	1	Ham sandwich	(*31*)
2007	*C. jejuni*	US: KS	13	0	Turkey, smoked	(*31*)
2007	*C.* spp.; *Salmonella*; norovirus	US: WI	229		Water, drinking	(*28*)
2007	*C.* spp.	US: WV	4		Water, drinking	(*28*)
2008	*C.* spp.	US: UT	50		Water, drinking	(*28*)
2008	*C. jejuni*	US: WV	8		Water, drinking	(*28*)
2008	*C.* spp.	Australia	2		Chicken	(*67*)
2008	*C.* spp.	Australia	4		Chicken	(*67*)
2008	*C.* spp.	Australia	4		Chicken liver pâté	(*67*)
2008	*C.* spp.	Australia	6		Chicken	(*68*)
2008	*C.jejuni*; *norovirus*	Switzerland	126		Water, drinking	(*22*)
2008	*C. jejuni*	US: RI	4	3	Chicken	(*31*)
2008	*C. jejuni*	US: NC	8	2	Chicken, BBQ	(*31*)
2008	*C. jejuni*	US: NY	268	7	Clams, raw and steamed	(*31*)
2008	*C. jejuni*	US: CO	5	1	Lettuce, homegrown	(*31*)
2008	*C. jejuni*	US: AK	132	5	Peas, green	(*47*)
2008	*C.* spp.	US: MI	27	0	Pork	(*31*)
2008	*C.* spp.	US: OR	10	0	Cheese: queso fresco	(*31*)
2008	*C. jejuni*	US: OH	3		Milk, raw	(*31*)
2008	*C. jejuni*	US: MA	8	0	Milk, raw	(*31*)
2008	*C.* spp.	US: MN	2	0	Milk, raw	(*31*)
2008	*C. jejuni*	US: MN	2	2	Milk, raw	(*31*)
2008	*C. jejuni*	US: PA	65	1	Milk, raw	(*31*)
2008	*C. jejuni*	US: UT	4	0	Milk, raw	(*31*)
2008	*C. coli*	US: ID	5		Milk, raw	(*31*)
2008	*C. jejuni*	US: CA	16		Milk, raw	(*31*)
2008	*C. jejuni*	US: ND	3	0	Milk, raw	(*31*)
2008	*C. jejuni*	US: TN	4	0	Milk, raw; water	(*31*)
2008	*C. jejuni*	US: WI	76	0	Beef, roast	(*31*)
2008	*C. jejuni*	US: FL	2		Chicken sandwich	(*31*)
2008	*C. jejuni*	US: WA	4	1	Turkey	(*31*)
2009	*C. jejuni*	Greece	60		Water, drinking	(*97*)
2009	*C. jejuni*	Korea	92		Chicken	(*179*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
2009	*C. jejuni*	Norway	12		Animal contact: lambs	(*121*)
2009	*C.* spp.	UK	59		Chicken liver pâté	(*171*)
2009	*C. jejuni*	US: MN	11	2	Lettuce	(*31*)
2009	*C. jejuni*	US: PA	9	1	Milk, whole, raw	(*31*)
2009	*C. jejuni*	US: PA	2	0	Milk, whole, raw	(*31*)
2009	*C. jejuni*	US: WI	52	1	Milk, whole, raw	(*31*)
2009	*C. jejuni*	US: CO	81	1	Milk, whole, raw	(*31*)
2009	*C. jejuni*	US: GA	11	0	Potato salad	(*31*)
2009	*C. jejuni*	US: UT	10	0	Cheese: queso fresco, raw	(*31*)
2009	*C. jejuni*	US: MA	70	2	Food, unknown	(*31*)
2009	*C.* spp.	Australia	4	0	Beef steak, salad	(*69*)
2009	*C.* spp.	Australia	35	0	Chicken liver parfait	(*69*)
2009	*C. jejuni*	US: AL	11		Water, river	(*80*)
2009	*C.* spp.; *Giardia*	US: ID	7		Water, drinking	(*80*)
2010	*C.* spp.	US: MO	67		Water, drinking	(*80*)
2010	*C. jejuni*	US: ID	3		Water, river	(*80*)
2010	*C. jejuni*	US: MO	16		Water, drinking	(*80*)
2010	*C. jejuni*	US: MT	101		Water, drinking	(*80*)
2010	*C. jejuni*; *Cryptosporidium*	US: PA	10		Water, drinking	(*80*)
2010	*C. jejuni*	US: UT	628		Water, drinking	(*80*)
2010	*C.* spp.	UK	24		Chicken liver parfait	(*87*)
2010	*C.* spp.	Scotland	18		Chicken, haggis terrine	(*154*)
2010	*C. jejuni*	Denmark	409		Water, drinking	(*73*)
2010	*C. jejuni*; *E. coli*; *Giardia*	Denmark	351		Water, recreational exposure	(*74*)
2010	*C.* spp.; *E. coli*	US: TN	6	1	Chicken, BBQ; sausage	(*31*)
2010	*C. jejuni*	US: FL	19	0	Broccoli; coleslaw; gravy	(*31*)
2010	*C. jejuni*	US: CO	3	0	Cheese curds	(*31*)
2010	*C.* spp.	US: AZ	15	1	Cheese, raw milk; milk, raw	(*31*)
2010	*C. jejuni*	US: PA	10	0	Chicken	(*31*)
2010	*C. jejuni*	US: NY	68	2	Clams, raw	(*31*)
2010	*C. jejuni*; STEC	US: CO	30	2	Milk, goat, raw	(*31*)
2010	*C. jejuni*	US: CO	2	0	Beef liver	(*31*)
2010	*C. jejuni*	US: MI	25	0	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: PA	22	3	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: MA	2	1	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: MI	11	0	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: VT	6	0	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: PA	4	1	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: SC	7	0	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: VT	11	0	Milk, whole, raw	(*31*)
2010	*C. jejuni*; *C. parvum*	US: MN	7	0	Milk, whole, raw	(*31*)
2010	*C. jejuni*	US: NY	20	1	Milk, raw	(*31*)
2010	*C. jejuni*	US: IL	2	0	Milk, raw	(*31*)
2010	*C. jejuni*	US: ND	7	0	Milk, whole, raw	(*31*)
2010	*C.* spp.	Australia	15	1	Food, unknown	(*71*)
2010	*C. jejuni*	Australia	10	0	Chicken	(*71*)
2010	*C. jejuni*	Australia	18	2	Chicken liver pâté	(*71*)
2010	*C. jejuni*	Australia	17	1	Food, unknown	(*71*)
2010	*C. jejuni*	Australia	23	1	Food, unknown	(*71*)
2010	*C. jejuni*	Australia	5	0	Chicken	(*71*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
2010	*C. jejuni*; *Giardia*; norovirus; rotavirus	Belgium	222		Water, drinking	(*181*)
2010–2011	*C. coli*	Canada	10		Person-to-person (sexual)	(*48*)
2011	*C. jejuni*	US: TX; Mexico	26		Water, drinking	(*90*)
2011	*C.* spp.	UK	18		Duck liver pâté	(*2*)
2011	*C. jejuni*	US: AK	11		Milk, raw	(*30*)
2011	*C. jejuni*	US: WY	2	0	Animal contact: sheep	(*168*)
2011	*C.* spp.	UK	11		Chicken liver	(*42*)
2011	*C. jejuni*; *C. coli*	UK	49		Chicken liver pâté	(*37*)
2011	*C. jejuni*	US: WA	4	0	Chicken	(*31*)
2011	*C.* spp.	US: OH	2	0	Milk, goat, raw	(*31*)
2011	*C. jejuni*	US: KS	18	0	Milk	(*31*)
2011	*C. jejuni*	US: PA	3	0	Milk, whole, raw	(*31*)
2011	*C.* spp.	US: PA	5	0	Milk, whole, raw	(*31*)
2011	*C. coli*	US: MN	3	2	Milk, whole, raw	(*31*)
2011	*C. jejuni*	US: MN	2	0	Milk, whole, raw	(*31*)
2011	*C. jejuni*	US: SC	10	2	Milk, whole, raw	(*31*)
2011	*C. coli*	US: NC	3		Milk, whole, raw	(*31*)
2011	*C. jejuni*	US: CT	3	0	Octopus	(*31*)
2011	*C.* spp.; *Vibrio* spp.; *Vibrio cholerae*	US: MA	4	1	Oysters, raw	(*31*)
2011	*C. jejuni*	US: SC	23	1	Milk, raw	(*31*)
2011	*C.* spp.	US: MI	2	0	Milk, raw	(*31*)
2011	*C. jejuni*	US: NY	4	0	Milk, raw	(*31*)
2011	*C. jejuni*	US: NY	3	0	Milk, raw	(*31*)
2011	*C. jejuni*	US: NY	13	0	Milk, raw	(*31*)
2011	*C.* spp.	US: VA	8	1	Turkey; stuffing	(*31*)
2011	*C. jejuni*	US: WI	16	1	Milk, whole, raw	(*31*)
2011	*C.* spp.	New Zealand	5		Chicken liver pâté	(*110*)
2011	*C.* spp.	New Zealand	3		Lamb's fry	(*110*)
2011	*C.* spp.	New Zealand	2		Lamb's fry	(*110*)
2011	*C.* spp.	New Zealand	9		Chicken liver mousse	(*110*)
2011	*C.* spp.	New Zealand	4		Milk, raw	(*110*)
2011	*C.* spp.	New Zealand	8		Milk, raw	(*110*)
2011	*C. jejuni*	Australia	4		Chicken kebabs	(*57*)
2011	*C. jejuni*	Australia	22	1	Water, drinking	(*70*)
2012	*C.* spp.	Scotland	27		Water, drinking	(*152*)
2012	*C.* spp.	Australia	15	1	Chicken liver pâté	(*132*)
2012	*C. spp*	Australia	7	0	Chicken liver pâté	(*130*)
2012	*C.* spp.	Australia	4	0	Chicken liver pâté	(*130*)
2012	*C. jejuni*	Australia	2	1	Foods, Chinese	(*72*)
2012	*C. jejuni*	New Zealand	138		Water, drinking (est. total cases 828–1987)	(*149*)
2012	*C. jejuni*; *C. coli*	UK	45		Duck liver pâté	(*178*)
2012	*C. coli*	US: NV	22	1	Water, muddy surface	(*180*)
2012	*C. jejuni*	US: NY	6	2	Milk, whole, raw	(*31*)
2012	*C.* other	US: PA	2	0	Milk, whole, raw	(*31*)
2012	*C. jejuni*	US: CO	3	1	Liver	(*31*)
2012	*C. jejuni*	US: MN	7	0	Milk, whole, raw	(*31*)
2012	*C. jejuni*	US: OH	15	1	Strawberry dessert,; ground beef; tea	(*31*)
2012	*C. jejuni*	US: MD	11	2	Chicken liver pâté	(*31*)
2012	*C.* spp.	US: WA	5	0	Milk, whole, raw	(*31*)
2012	*C. jejuni*	US: PA	3	0	Milk, whole, raw	(*31*)

Year	Species	Location	Cases	Hosp.	Vehicle	Reference
2012	*C.* unknown; *C. jejuni*	US: OH	51	2	Fruit salad	(*31*)
2012	*C.* spp.	US: TN	15	0	Salad	(*31*)
2012	*C. jejuni*	US: CA	11	0	Chicken	(*31*)
2012	*C. jejuni*	US: OH	2	0	Milk, whole, raw	(*31*)
2012	*C.* spp.	US: OH	4	0	Milk, whole, raw	(*31*)
2012	*C. jejuni*	US: UT	2	0	Cheese curds	(*31*)
2012	*C. jejuni*	US: OR	9	0	Chicken liver pâté	(*31*)
2012	*C. jejuni*	US: PA	10	0	Milk, whole, raw	(*31*)
2012	*C. jejuni*	US: CA	33	2	Milk	(*31*)
2012	*C. jejuni*	US: 3 states	6	1	Chicken, liver	(*165*)
2012	*C.* spp.	US: PA	4	0	Duck	(*31*)
2012	*C. jejuni*; *S. enterica*	US: WI	21	5	Beef intestine soup; beef, minced	(*31*)
2012	*C. jejuni*	US: 4 states	148	10	Milk, whole, raw	(*111*)
2013	*C. jejuni*	US: PA	8		Milk, raw	(*170*)
2013	*C. jejuni*	Australia	17	1	Duck liver parfait	(*81*)
2014	*C. jejuni*	US: WI	38		Milk, raw	(*190*)

**Some outbreaks with a small number of cases and no suspected vehicle were omitted from this chart.*

References

1. Abe T, Haga S, Yokoyama K, Watanabe N. 2008. An outbreak of Campylobacter jejuni subsp jejuni infection via tap water. Jap J Infect Dis 61:327
2. Abid M, Wimalarathna H, Mills J, Saldana L, Pang W, Richardson JF, Maiden MCH, McCarthy ND. 2013. Duck liver-associated outbreak of Campylobacter infection among humans, United Kingdom, 2011. Emerg Infect Dis 19:1310-3
3. Aho M, Kurki M, Rautelin H, Kosunen TU. 1989. Waterborne outbreak of Campylobacter enteritis after outdoors infantry drill in Utti, Finland. Epidemiol Infect 103:133-41
4. Alary M, Nadeau D. 1990. An outbreak of Campylobacter enteritis associated with a community water-supply. Can J Public Health 81:268-71
5. Allerberger F, Al-Jazrawi N, Kreidl P, Dierich MP, Feierl G, Hein I, Wagner M. 2003. Barbecued chicken causing a multi-state outbreak of Campylobacter jejuni enteritis. Infection 31:19-23
6. Amato S, Maragno M, Mosele P, Sforzi M, Mioni R, Barco L, Dala Pozza MC, Antonello K, Ricci A. 2007. An outbreak of Campylobacter jejuni linked to the consumption of raw milk in Italy. Zoonoses Public Health 54:23
7. Andersson Y, Dejong B, Studahl A. 1997. Waterborne Campylobacter in Sweden: the cost of an outbreak. Water Sci Technol 35:11-4
8. Anon. 1984. Disease associated with milk and dairy products: 1982. Brit Med J 288:466-7
9. Anon. 2000. Outbreak of Campylobacter infection in a south Wales valley. Commun Dis Rep Weekly 10:427-8
10. Beaudeau P, De Valk H, Vaillant V, Mannschott C, Tillier C, Mouly D, Ledrans M. 2008. Lessons learned from ten investigations of waterborne gastroenteritis outbreaks, France, 1998–2006. J Water Health 6:491-503
11. Benda B, Pollak J, Benjamin R, Livermore T, Mitchell H, Werner SB, Chin J. 1986. Campylobacter outbreak associated with raw milk provided on a dairy tour — California. Morbid Mortal Weekly Rep 35:311-2
12. Birkhead G, Vogt RL, Heun E, Evelti CM, Patton CM. 1988. A multiple-strain outbreak of Campylobacter enteritis due to consumption of inadequately pasteurized milk. J Infect Dis 157:1095-7
13. Black AP, Kirk MD, Millard G. 2006. Campylobacter outbreak due to chicken consumption at an Australian Capital Territory restaurant. Commun Dis Intell 30:373-7
14. Blackburn BG, Craun GF, Yoder JS, Hill V, Calderon RL, Chen N, Lee SH, Levy DA, Beach MJ. 2004. Surveillance for waterborne-disease outbreaks associated with drinking water — United States, 2001–2002. Morbid Mortal Weekly Rep 53:23-44
15. Blaser MJ, Cravens J, Powers BW, Laforce FM, Wang WLL. 1979. Campylobacter enteritis associated with unpasteurized milk. Am J Med 67:715-8
16. Blaser MJ, Checko P, Bopp C, Bruce A, Hughes JM. 1982. Campylobacter enteritis associated with foodborne transmission. Am J Epidemiol 116:886-94
17. Blaser MJ, Hardesty HL, Wang WL, Edell TA. 1979. Campylobacter enteritis in a household — Colorado. Morbid Mortal Week Rep 28:273-4
18. Blaser MJ, Penner JL, Wells JG. 1982. Diversity of serotypes in outbreaks of enteritis due to Campylobacter jejuni. J Infect Dis 146:826
19. Blaser MJ, Waldman RJ, Barrett T, Erlandson AL. 1981. Outbreaks of Campylobacter enteritis in 2 extended families — evidence for person-to-person transmission. J Pediatr 98:254-7
20. Blessing DJ, Thompson M, Fisher B, Schooley D, Kramer MJ, DeMelfi TM, McCarthy MA, Witte EJ, Hays CW, Smucker J. 1983. Campylobacteriosis associated with raw milk consumption — Pennsylvania. Morbid Mortal Weekly Rep 32:337-44
21. Bowen AB, Fry A, Richards G, Beuchat L. 2006. Infections associated with cantaloupe consumption: a public health concern. Epidemiol Infect 134:675-85
22. Breitenmoser A, Fretz R, Schmid J, Besl A, Etter R. 2011. Outbreak of acute gastroenteritis due to a washwater-contaminated water supply, Switzerland, 2008. J Water Health 9:569-76
23. Bremell T, Bjelle A, Svedhem Å. 1991. Rheumatic symptoms following an outbreak of Campylobacter enteritis — a 5-year follow-up. Ann Rheumatic Dis 50:934-8
24. Brieseman MA. 1984. Raw-milk consumption as a probable cause of 2 outbreaks of Campylobacter infection. N Z Med J 97:411-3
25. Brieseman MA. 1987. Town water-supply as the cause of an outbreak of Campylobacter infection. N Z Med J 100:212-3
26. Broczyk A, Thompson S, Smith D, Lior H. 1987. Water-borne outbreak of Campylobacter laridis-associated gastroenteritis. Lancet 1:164-5
27. Brouwer R, Mertens MJA, Siem TH, Katchaki J. 1979. Explosive outbreak of Campylobacter enteritis in soldiers. Antonie Van Leeuwenhoek. J Microbiology 45:517-9
28. Brunkard JM, Ailes EC, Roberts V, Hill V, Hilborn ED, Craun GF, Rajasingham A, Kahler A, Garrison L, Hicks L, Carpenter J, Wade TJ, Beach MJ, Yoder JS. 2011. Surveillance for waterborne disease outbreaks associated with drinking water — United States, 2007–2008. Morbid Mortal Weekly Rep 60:38-75
29. Canada HaW. 1981. Campylobacter enteritis associated with the consumption of raw milk — Alberta. Canada Dis Weekly Rep 7:20
30. Castrodale LJ, Gerlach RF, Xavier CM, Smith BJ, Cooper MP, McLaughlin JB. 2013. Sharing milk but not messages: campylobacteriosis associated with consumption of raw milk from a cow-share program in Alaska, 2011. J Food Prot 76:744-7

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

31. Centers for Disease Control and Prevention. Foodborne Outbreak Online Database. http://wwwn.cdc.gov/foodborneoutbreaks/Default.aspx
32. Christenson B, Ringner A, Blücher C, Billaudelle H, Gundtoft KN, Eriksson G, Böttiger M. 1983. An outbreak of Campylobacter enteritis among the staff of a poultry abattoir in Sweden. Scan J Infect Dis 15:167-72
33. Clark CG, Price L, Ahmed R, Woodward DL, Melito PL, Rodgers FG, Jamieson F, Ciebin B, Li A, Ellis A. 2003. Characterization of waterborne outbreak-associated Campylobacter jejuni, Walkerton, Ontario. Emerg Infect Dis 9:1232-41
34. Cohen DI, Rouach TM, Rogol M. 1984. A Campylobacter jejuni enteritis outbreak in a military base in Israel. Isr J Med Sci 20:217-8
35. Dahl OP, Melby K. 1987. Clinical findings in waterborne outbreak of Campylobacter jejuni. Tidsskrift for Den Norske Laegeforening 107:349-403
36. Duke LA, Breathnach AS, Jenkins DR, Harkis BA, Codd AW. 1996. A mixed outbreak of Cryptosporidium and Campylobacter infection associated with a private water supply. Epidemiol Infect 116:303-8
37. Edwards DS, Milne LM, Morrow K, Sheridan P, Verlander NQ, Mulla R, Richardson JF, Pender A, Lilley M, Reacher M. 2014. Campylobacteriosis outbreak associated with consumption of undercooked chicken liver pâté in the East of England, September 2011: identification of a dose-response risk. Epidemiol Infect 142:352-7
38. Ellis A, Irwin R, Hockin J, Borczyk A, Woodward D, Johnson W. 1995. Outbreak of Campylobacter infection among farm workers: an occupational hazard. Canada Commun Dis Rep 21:153-6
39. Evans MR, Lane W, Frost JA, Nylen G. 1998. A Campylobacter outbreak associated with stir-fried food. Epidemiol Infect 121:275-9
40. Evans MR, Roberts RJ, Ribeiro CD, Gardner D, Kembrey D. 1996. A milk-borne Campylobacter outbreak following an educational farm visit. Epidemiol Infect 117:457-62
41. Fahey T, Morgan D, Gunneburg C, Adak GK, Majid F, Kaczmarski E. 1995. An outbreak of Campylobacter jejuni enteritis associated with failed milk pasteurization. J Infect 31:137-43
42. Farmer S, Keenan A, Vivancos R. 2012. Food-borne Campylobacter outbreak in Liverpool associated with cross-contamination from chicken liver parfait: implications for investigation of similar outbreaks. Public Health 126:657-9
43. Finch MJ, Blake PA. 1985. Foodborne outbreaks of campylobacteriosis — the United States experience, 1980–1982. Am J Epidemiol 122:262-8
44. Forbes KJ, Gormley FJ, Dallas JF, Labovitiadi O, MacRae M, Owen RJ, Richardson J, Strachan NJC, Cowden JM, Ogden ID, McGuigan CC. 2009. Campylobacter immunity and coinfection following a large outbreak in a farming community. J Clin Microbiol 47:111-6
45. Furtado C, Adak GK, Stuart JM, Wall PG, Evans HS, Casemore DP. 1998. Outbreaks of waterborne infectious intestinal disease in England and Wales, 1992–5. Epidemiol Infect 121:109-19
46. Gallay A, De Valk H, Cournot M, Ladeuil B, Hemery C, Castor C, Bon F, Mégraud F, Le Cann P, Desenclos JC. 2006. A large multi-pathogen waterborne community outbreak linked to faecal contamination of a groundwater system, France, 2000. Clin Microbiol Infect 12:561-70
47. Gardner TJ, Fitzgerald C, Xavier C, Klein R, Pruckler J, Stroika S, McLaughlin JB. 2011. Outbreak of campylobacteriosis associated with consumption of raw peas. Clin Infect Dis 53:26-32
48. Gaudreau C, Helferty M, Sylvestre JL, Allard R, Pilon PA, Poisson M, Bekal S. 2013. Campylobacter coli outbreak in men who have sex with men, Quebec, Canada, 2010–2011. Emerg Infect Dis 19:764-7
49. Gaudreau C, Michaud S. 2003. Cluster of erythromycin- and ciprofloxacin-resistant Campylobacter jejuni subsp jejuni from 1999 to 2001 in men who have sex with men, Quebec, Canada. Clin Infect Dis 37:131-6
50. Gent RN, Telford DR, Syed Q. 1999. An outbreak of Campylobacter food poisoning at a university campus. Commun Dis Public Health 2:39-42
51. Ginsberg MM, Thompson MA, Peter CR, Ramras DG, Chin J. 1981. Campylobacter sepsis associated with "nutritional therapy" — California. Morbid Mortal Week Rep 30:294-5
52. Goodman LJ, Harris AA, Sokalski SJ, Kellie S, Barrett JE, Ruthe A, Finn A, Kaplan RL. 1983. A restaurant associated Campylobacter outbreak. Eur J Clin Microbiol Infect Dis 2:394-5
53. Goossens H, Giesendorf BAJ, Vandamme P, Vlaes L, Van den Borre C, Koeken A, Quint WGV, Blomme W, Hanicq P, Koster DS, Hofstra H, Butzler JP, Van der Plas J. 1995. Investigation of an outbreak of Campylobacter upsaliensis in day care centers in Brussels — analysis of relationships among isolates by phenotypic and genotypic typing methods. J Infect Dis 172:1298-305
54. Goossens H, Kremp L, Boury R, Vlaes L, Van den Borre C, Henocque G, Rocque J, Alanio G, Hemelhof W, Macart M, Butzler JP. 1986. Nosocomial outbreak of Campylobacter jejuni meningitis in newborn infants. Lancet 2:146-9
55. Graham C, Whyte R, Gilpin B, Cornelius A, Hudson JA, Morrison D, Graham H, Nicol C. 2005. Outbreak of campylobacteriosis following pre-cooked sausage consumption. Austral N Zealand J Public Health 29:507-10
56. Graves TK, Bradley KK, Crutcher JM. 1998. Outbreak of Campylobacter enteritis associated with cross-contamination of food — Oklahoma, 1996. Morbid Mortal Weekly Rep 47:129-31
57. Group O. 2011. OzFoodNet quarterly report, 1 April to 30 June 2011. Commun Dis Intell 35:312-4
58. Group OW. 2001. OzFoodNet: enhancing foodborne disease surveillance across Australia: quarterly report, January to March 2001. Commun Dis Intell 25:103-6
59. Group OW. 2002. Communicable diseases surveillance: highlights for 4th quarter, 2001. Commun Dis Intell 26:65-73
60. Group OW. 2002. OzFoodNet: enhancing foodborne disease surveillance across Australia: quarterly report, July to September 2001. Commun Dis Intell 26:22-7
61. Group OW. 2003. Foodborne disease in Australia: incidence, notifications and outbreaks. annual report of the OzFoodNet Network, 2002. Commun Dis Intell 27:209-39
62. Group OW. 2004. Foodborne disease investigation across Australia: annual report of the OzFoodNet Network, 2003. Commun Dis Intell 28:359-89
63. Group OW. 2005. Reported foodborne illness and gastroenteritis in Australia: annual report of the OzFoodNet Network, 2004. Commun Dis Intell 29:165-92
64. Group OW. 2006. Burden and causes of foodborne disease in Australia: annual report of the OzFoodNet Network, 2005. Commun Dis Intell 30:278-300
65. Group OW. 2007. Monitoring the incidence and causes of diseases potentially transmitted by food in Australia: annual report of the OzFoodNet Network, 2006. Commun Dis Intell 31:345-65
66. Group OW. 2008. Monitoring the incidence and causes of diseases potentially transmitted by food in Australia: annual report of the OzFoodNet Network, 2007. Commun Dis Intell 32:400-24
67. Group Ow. 2008. OzFoodNet quarterly report, 1 January to 31 March 2008. Commun Dis Intell 32:267-71
68. Group OW. 2009. OzFoodNet quarterly report, 1 October to 31 December 2008. Commun Dis Intell 33:53-8
69. Group OW. 2010. Monitoring the incidence and causes of diseases potentially transmitted by food in Australia: annual report of the OzFoodNet Network, 2009. Commun Dis Intell 34:396-426
70. Group OW. 2011. OzFoodNet quarterly report, 1 October to 31 December 2011. Commun Dis Intell 36:E294- E5
71. Group OW. 2012. Monitoring the incidence and causes of diseases potentially transmitted by food in Australia: annual report of the OzFoodNet network, 2010. Commun Dis Intell 36:213-40
72. Group OW. 2014. OzFoodNet enhanced foodborne disease surveillance, 1 January to 31 March 2013. Commun Dis Intell 38:E70-E2
73. Gubbels SM, Kuhn KG, Larsson JT, Adelhardt M, Engberg J, Ingildsen P, Hollesen LW, Muchitsch S, Mølbak K, Ethelberg S. 2012. A waterborne outbreak with a single clone of Campylobacter jejuni in the Danish town of Køge in May 2010. Scan J Infect Dis 44:586-94
74. Harder-Lauridsen NM, Kuhn KG, Erichsen AC, Mølbak K, Ethelberg S. 2013. Gastrointestinal illness among triathletes swimming in non-polluted versus polluted seawater affected by heavy rainfall, Denmark, 2010–2011. PLoS One 8:e78371
75. Harrington P, Archer J, Davis JP, Croft DR, Varma JK. 2002. Outbreak of Campylobacter jejuni infections associated with drinking unpasteurized milk procured through a cow-leasing program — Wisconsin, 2001. Morbid Mortal Weekly Rep 51:548-9
76. Harris NV, Kimball TJ, Bennett P, Johnson Y, Wakely D, Nolan CM. 1987. Campylobacter jejuni enteritis associated with raw goat's milk. Am J Epidemiol 126:179-86
77. Hennessy EP. 2004. An outbreak of campylobacteriosis amongst directing staff and students at the infantry training centre, Brecon, Wales, March 2004. J Royal Army Med Corps 150:175-8
78. Hershkowici S, Barak M, Cohen A, Montag J. 1987. An outbreak of Campylobacter jejuni infection in a neonatal intensive care unit. J Hosp Infect 9:54-9

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

79. Heryford AG, Seys SA. 2004. Outbreak of occupational campylobacteriosis associated with a pheasant farm. J Agr Safety Health 10:127-32
80. Hilborn ED, Wade TJ, Hicks L, Garrison L, Carpenter J, Adam E, Mull B, Yoder J, Roberts V, Gargano JW. 2013. Surveillance for waterborne disease outbreaks associated with drinking water and other nonrecreational water — United States, 2009–2010. Morbid Mortal Weekly Rep 62:714-20
81. Hope KG, Merritt TD, Durrheim DN. 2014. Short incubation periods in Campylobacter outbreaks associated with poultry liver dishes. Commun Dis Intell 38:E20-E3
82. Hrudey SE, Payment P, Huck PM, Gillham RW, Hrudey EJ. 2003. A fatal waterborne disease epidemic in Walkerton, Ontario: comparison with other waterborne outbreaks in the developed world. Water Sci Technol 47:7-14
83. Hudson PJ, Vogt RL, Brondum J, Patton CM. 1984. Isolation of Campylobacter jejuni from milk during an outbreak of campylobacteriosis. J Infect Dis 150:789
84. Hunt DC, Bañez Ocfemia MC, Neises D, Hansen G, Aghoghovbia ST. 2009. Campylobacter jejuni infection associated with unpasteurized milk and cheese — Kansas, 2007. Morbid Mortal Week Rep 57:1377-9
85. Hutchinson DN, Bolton FJ, Hinchliffe PM, Dawkins HC, Horsley SD, Jessop EG, Robertshaw PA, Counter DE. 1985. Evidence of udder excretion of Campylobacter jejuni as the cause of milk-borne Campylobacter outbreak. J Hyg 94:205-15
86. Hutchinson DN, Bolton FJ, Jelley WCN, Mathews WG, Telford DR, Counter DE, Jessop EG, Horsley SD. 1985. Campylobacter enteritis associated with consumption of raw goat's milk. Lancet 1:1037-8
87. Inns T, Foster K, Gorton R. 2010. Cohort study of a campylobacteriosis outbreak associated with chicken liver parfait, United Kingdom, June 2010. Euro Surveil 15:2-5
88. Istre GR, Blaser MJ, Shillam P, Hopkins RS. 1984. Campylobacter enteritis associated with undercooked barbecued chicken. Am J Public Health 74:1265-7
89. Itoh T, Saito K, Maruyama T, Sakai S, Ohashi M, Oka A. 1980. An outbreak of acute enteritis due to Campylobacter fetus subspecies jejuni at a nursery-school in Tokyo. Microbiol Immunol 24:371-9
90. Jackson BR, Alomía Zegarra J, López-Gatell H, Sejvar J, Arzate F, Waterman S, Sánchez Núñez A, López B, Weiss J, Quintero Cruz R, López Murrieta DY, Luna-Gierke R, Heiman K, Vieira AR, Fitzgerald C, Kwan P, Zárate-Bermúdez M, Talkington D, Hill VR, Mahon B. 2013. Binational outbreak of Guillain–Barré syndrome associated with Campylobacter jejuni infection, Mexico and USA, 2011. Epidemiol Infect 142:1089-99
91. Jakopanec I, Borgen K, Vold L, Lund H, Forseth T, Hannula R, Nygård K. 2008. A large waterborne outbreak of campylobacteriosis in Norway: the need to focus on distribution system safety. BMC Infect Dis 8:128
92. Jay-Russell MT, Mandrell RE, Yuan J, Bates A, Manalac R, Mohle-Boetani J, Kimura A, Lidgard J, Miller WG. 2013. Using major outer membrane protein typing as an epidemiological tool to investigate outbreaks caused by milk-borne Campylobacter jejuni isolates in California. J Clin Microbiol 51:195-201
93. Jimenez M, Soler P, Venanzi JD, Cante P, Varela C, Martinez Navarro F. 2005. An outbreak of Campylobacter jejuni enteritis in a school of Madrid, Spain. Euro Surveill 10:118-21
94. Jones IG, Roworth M. 1996. An outbreak of Escherichia coli O157 and campylobacteriosis associated with contamination of a drinking water supply. Public Health 110:277-82
95. Jones PH, Willis AT, Robinson DA, Skirrow MB, Josephs DS. 1981. Campylobacter enteritis associated with the consumption of free-school milk. J Hyg 87:155-62
96. Kalman M, Szollosi E, Czermann B, Zimanyi M, Szekeres S, Kalman M. 2000. Milkborne Campylobacter infection in Hungary. J Food Protection 63:1426-9
97. Karagiannis I, Sideroglou T, Gkolfinopoulou K, Tsouri A, Lampousaki D, Velonakis EN, Scoulica EV, Mellou K, Panagiotopoulos T, Bonovas S. 2010. A waterborne Campylobacter jejuni outbreak on a Greek island. Epidemiol Infect 138:1726-34
98. Klein BS, Vergeront JM, Blaser MJ, Edmonds P, Brenner DJ, Janssen D, Davis JP. 1986. Campylobacter infection associated with raw-milk — an outbreak of gastroenteritis due to Campylobacter jejuni and thermotolerant Campylobacter fetus subsp fetus. J Am Med Assoc 255:361-4
99. Korlath JA, Osterholm MT, Judy LA, Forfang JC, Robinson RA. 1985. A point-source outbreak of campylobacteriosis associated with consumption of raw-milk. J Infect Dis 152:592-6
100. Kornblatt AN, Barrett T, Morris GK, Tosh FE. 1985. Epidemiologic and laboratory investigation of an outbreak of Campylobacter enteritis associated with raw milk. Am J Epidemiol 122:884-9
101. Kramer MH, Herwaldt BL, Craun GF, Calderon RL, Juranek DD. 1996. Surveillance for waterborne-disease outbreaks — United States, 1993–1994. Morbid Mortal Weekly Rep 45:1-33
102. Kuusi M, Klemets P, Miettinen I, Laaksonen I, Sarkkinen H, Hänninen ML, Rautelin H, Kela E, Nuorti JP. 2004. An outbreak of gastroenteritis from a non-chlorinated community water supply. J Epidemiol Commun Health 58:273-7
103. Kuusi M, Nuorti JP, Hänninen ML, Koskela M, Jussila V, Kela E, Miettinen I, Ruutu P. 2005. A large outbreak of campylobacteriosis associated with a municipal water supply in Finland. Epidemiol Infect 133:593-601
104. Laine J, Huovinen E, Virtanen MJ, Snellman M, Lumio J, Ruutu P, Kujansuu E, Vuento R, Pitkänen T, Miettinen I, Herrala J, Lepistö O, Antonen J, Helenius J, Hänninen ML, Maunula L, Mustonen J, Kuusi M. 2011. An extensive gastroenteritis outbreak after drinking-water contamination by sewage effluent, Finland. Epidemiol Infect 139:1105-13
105. Lee SH, Levy DA, Craun GF, Beach MJ, Calderon RL. 2002. Surveillance for waterborne-disease outbreaks — United States, 1999–2000. Morbid Mortal Weekly Rep 51:1-47
106. Lehner A, Schneck C, Feierl G, Pless P, Deutz A, Brandl E, Wagner M. 2000. Epidemiologic application of pulsed-field gel electrophoresis to an outbreak of Campylobacter jejuni in an Austrian youth centre. Epidemiol Infect 125:13-6
107. Levy AJ. 1946. A gastro-enteritis outbreak probably due to a bovine strain of Vibrio. Yale J Biol Med 18:243-55
108. Levy DA, Bens MS, Craun GF, Calderon RL, Herwaldt BL. 1998. Surveillance for waterborne-disease outbreaks: United States, 1995–1996. Morbid Mortal Weekly Rep 47:1-34
109. Liang JL, Dziuban EJ, Craun GF, Hill V, Moore MR, Gelting RJ, Calderon RL, Beach MJ, Roy SL. 2006. Surveillance for waterborne disease and outbreaks associated with drinking water and water not intended for drinking — United States, 2003–2004. Morbid Mortal Weekly Rep 55:31-65
110. Lim E, Lopez L, Borman A, Cressey P, Pirie R. 2012. Foodborne disease in New Zealand 2011. http://www.foodsafety.govt.nz/elibrary/industry/foodborne-disease-nz-doc.pdf
111. Longenberger AH, Palumbo AJ, Chu AK, Moll ME, Weltman A, Ostroff SM. 2013. Campylobacter jejuni infections associated with unpasteurized milk — multiple states, 2012. Clin Infect Dis 57:263-6
112. Maurer AM, Sturchler D. 2000. A waterborne outbreak of small round structured virus, Campylobacter and Shigella co-infections in La Neuveville, Switzerland, 1998. Epidemiol Infect 125:325-32
113. Mazick A, Ethelberg S, Nielsen EM, Mølbak K, Lisby M. 2006. An outbreak of Campylobacter jejuni associated with consumption of chicken, Copenhagen, 2005. Euro Surveil 11:137-9
114. McNaughton RD, Leyland R, Mueller L. 1982. Outbreak of Campylobacter enteritis due to consumption of raw milk. Canad Med Assoc J 126:657-8
115. Melby K, Gondrosen B, Gregusson S, Ribe H, Dahl OP. 1991. Waterborne campylobacteriosis in northern Norway. Int J Food Microbiology 12:151-6
116. Melby KK, Svendby JG, Eggebø T, Holmen LA, Andersen BM, Lind L, Sjøgren, Kaijser B. 2000. Outbreak of Campylobacter infection in a subartic community. Eur J Clin Microbiol Infect Dis 19:542-4
117. Mentzing LO. 1981. Waterborne outbreaks of Campylobacter enteritis in central Sweden. Lancet 2:352-4
118. Merritt A, Miles R, Bates J. 1999. An outbreak of Campylobacter enteritis on an island resort, North Queensland. Commun Dis Intell 23:215-20
119. Millson M, Bokhout M, Carlson J, Spielberg L, Aldis R, Borczyk A, Lior J. 1991. An outbreak of Campylobacter jejuni gastroenteritis linked to meltwater contamination of a municipal well. Can J Public Health 82:27-31
120. Moffatt CRM, Cameron S, Mickan L, Givney RC. 2010. Campylobacter jejuni gastroenteritis at an Australian boarding school: consistency between epidemiology, flaA typing, and multilocus sequence typing. Foodborne Pathog Dis 7:1285-90
121. Møller-Stray J, Eriksen HM, Bruheim T, Kapperud G, Lindstedt BA, Skeie Å, Sunde M, Urdahl AM, Øygard B, Vold L. 2012. Two outbreaks of diarrhoea in nurseries in Norway after farm visits, April to May 2009. Euro Surveil 17:20-6

122. Moore JE, Stanley T, Smithson R, O'Malley H, Murphy PG. 2000. Outbreak of Campylobacter food-poisoning in Northern Ireland. Clin Microbiol Infect 6:399-400
123. Morgan D, Gunneberg C, Gunnell D, Healing TD, Lamerton S, Soltanpoor N, Lewis DA, White DG. 1994. An outbreak of Campylobacter infection associated with the consumption of unpasteurized milk at a large festival in England. Eur J Epidemiol 10:581-5
124. Morooka T, Takeo H, Takeshita S, Mimatsu T, Yukitake K, Oda T. 1988. Nosocomial meningitis due to Campylobacter fetus subsp fetus in a neonatal intensive-care unit. Eur J Pediatr 148:89-90
125. Murphy O, Gray J, Gordon S, Bint AJ. 1995. An outbreak of Campylobacter food poisoning in a health-care setting. J Hosp Infect 30:225-8
126. Novello A. 1999. Outbreak of Escherichia coli O157:H7 and Campylobacter among attendees of the Washington County fair — New York, 1999. Morbid Mortal Weekly Rep 48:803-5
127. O'Leary MC, Harding O, Fisher L, Cowden J. 2009. A continuous common-source outbreak of campylobacteriosis associated with changes to the preparation of chicken liver pâté. Epidemiol Infect 137:383-8
128. O'Reilly CE, Bowen AB, Perez NE, Sarisky JP, Shepherd CA, Miller MD, Hubbard BC, Herring M, Buchanan SD, Fitzgerald C, Hill V, Arrowood MJ, Xiao LX, Hoekstra RM, Mintz ED, Lynch MF. 2007. A waterborne outbreak of gastroenteritis with multiple etiologies among resort island visitors and residents: Ohio, 2004. Clin Infect Dis 44:506-12
129. Olsen SJ, Hansen GR, Bartlett L, Fitzgerald C, Sonder A, Manjrekar R, Riggs T, Kim J, Flahart R, Pezzino G, Swerdlow DL. 2001. An outbreak of Campylobacter jejuni infections associated with food handler contamination: the use of pulsed-field gel electrophoresis. J Infect Dis 183:164-7
130. OzFoodNet Working G. 2013. OzFoodNet quarterly report, 1 April to 30 June 2012. Commun Dis Intell 37:E73-E8
131. Palmer SR, Gully PR, White JM, Pearson AD, Suckling WG, Jones DM, Rawes JCL, Penner JL. 1983. Water-borne outbreak of Campylobacter gastroenteritis. Lancet 1:287-90
132. Parry A, Fearnley E, Denehy E. 2012. 'Surprise': outbreak of Campylobacter infection associated with chicken liver pâté at a surprise birthday party, Adelaide, Australia, 2012. Western Pac Surveill Response J 3:16-9
133. Pearson AD, Greenwood MH, Donaldson J, Healing TD, Jones DM, Shahamat M, Feltham RKA, Colwell RR. 2000. Continuous source outbreak of campylobacteriosis traced to chicken. J Food Prot 63:309-14
134. Peterson MC. 2003. Campylobacter jejuni enteritis associated with consumption of raw milk. J Environ Health 65:20-1
135. Porter IA, Reid TMS. 1980. A milk-borne outbreak of Campylobacter infection. J Hyg 84:415-9
136. Potter ME, Blaser MJ, Sikes RK, Kaufmann AF, Wells JG. 1983. Human Campylobacter infection associated with certified raw-milk. Am J Epidemiol 117:475-83
137. Prevention CfDCa. 1984. Campylobacter outbreak associated with certified raw milk products — California. Morbid Mortal Weekly Rep 33:562
138. Raupach JCA, Hundy RL. 2003. An outbreak of Campylobacter jejuni infection among conference delegates. Commun Dis Intell 27:380-3
139. Richardson G, Thomas DR, Smith RMM, Nehaul L, Ribeiro CD, Brown AG, Salmon RL. 2007. A community outbreak of Campylobacter jejuni infection from a chlorinated public water supply. Epidemiol Infect 135:1151-8
140. Riordan T, Humphrey TJ, Fowles A. 1993. A point-source outbreak of Campylobacter infection related to bird-pecked milk. Epidemiol Infect 110:261-5
141. Robinson DA, Jones DM. 1981. Milk-borne Campylobacter infection. British Medical Journal 282:1374-6
142. Roels TH, Wickus B, Bostrom HH, Kazmierczak JJ, Nicholson MA, Kurzynski TA, Davis JP. 1998. A foodborne outbreak of Campylobacter jejuni (O:33) infection associated with tuna salad: a rare strain in an unusual vehicle. Epidemiol Infect 121:281-7
143. Rogol M, Sechter I, Falk H, Shtark Y, Alfi S, Greenberg Z, Mizrachi R. 1983. Waterborne outbreak of Campylobacter enteritis. Eur J Clin Microbiol Infect Dis 2:588-90
144. Ronveaux O, Quoilin S, Van Loock F, Lheureux P, Struelens M, Butzler JP. 2000. A Campylobacter coli foodborne outbreak in Belgium. Acta Clin Belgica 55:307-11
145. Rosenfield JA, Arnold GJ, Davey GR, Archer RS, Woods WH. 1985. Serotyping of Campylobacter jejuni from an outbreak of enteritis implicating chicken. J Infect 11:159-65
146. Sacks JJ, Lieb S, Baldy LM, Berta S, Patton CM, White MC, Bigler WJ, Witte JJ. 1986. Epidemic campylobacteriosis associated with a community water supply. Am J Public Health 76:424-9
147. Schaefer JR, Conklin EV, Bunce DO, Storck RD, Arnold FK, Viner JP, Merritt FB, Drish, Roth AJ, Currier RW, Wintermeyer LA, Davis JP. 1979. Campylobacter enteritis — Iowa. Morbid Mortal Week Rep 28:565-6
148. Schildt M, Savolainen S, Hanninen ML. 2006. Long-lasting Campylobacter jejuni contamination of milk associated with gastrointestinal illness in a farming family. Epidemiol Infect 134:401-5
149. Sheerin I, Bartholomew N, Brunton C. 2014. Estimated community costs of an outbreak of campylobacteriosis resulting from contamination of a public water supply in Darfield, New Zealand. N Z Med J 127:13-21
150. Skirrow MB, Fidoe RG, Jones DM. 1981. An outbreak of presumptive foodborne Campylobacter enteritis. J Infect 3:234-6
151. Sloan DSG, Morrison A. 1995. A waterborne outbreak of campylobacteriosis on the isle of Coll. Scot Cent Infect Environ Health 29:70-1
152. Smith-Palmer A. 2013. General outbreaks of infectious intestinal disease reported to HPS in the third quarter of 2012. HPS Weekly Report 47:8-9
153. Smith-Palmer A, Brownlie S. 2007. Gastro-intestinal and foodborne infections: general outbreaks of infectious intestinal disease reported to Obsurv during the first quarter of 2007. HPS Weekly Report 41:(27 June 2007)
154. Smith-Palmer A, Cowden J. 2011. Gastro-intestinal and foodborne infections: general outbreaks of infectious intestinal disease reported to HPS during 2010. HPS Weekly Report 45:291-8
155. Smith KE, Stenzel SA, Bender JB, Wagstrom E, Soderlund D, Leano FT, Taylor CM, Belle-Isle PA, Danila R. 2004. Outbreaks of enteric infections caused by multiple pathogens associated with calves at a farm day camp. Pediatr Infect Dis J 23:1098-104
156. St. Louis ME. 1988. Water-related disease outbreaks, 1985. Morbid Mortal Week Rep 37:15-24
157. Stehr-Green J, Mitchell P, Nicholls C, McEwan S, Payne A. 1991. Campylobacter enteritis — New Zealand, 1990. Morbid Mortal Weekly Rep 40:116-23
158. Steinmuller N, Demma L, Bender JB, Eidson M, Angulo FJ. 2006. Outbreaks of enteric disease associated with animal contact: not just a foodborne problem anymore. Clin Infect Dis 43:1596-602
159. Stuart J, Sufi F, Mcnulty C, Park P. 1997. Outbreak of Campylobacter enteritis in a residential school associated with bird pecked bottle tops. Commun Dis Report 7:R38-40
160. Stuart TL, Sandhu J, Stirling R, Corder J, Ellis A, Misa P, Goh S, Wong B, Martiquet P, Hoang L, Galanis E. 2010. Campylobacteriosis outbreak associated with ingestion of mud during a mountain bike race. Epidemiol Infect 138:1695-703
161. Taylor DN, Brown M, McDermott KT. 1983. Waterborne transmission of Campylobacter enteritis. Microb Ecol 8:347-54
162. Taylor DN, Porter BW, Williams CA, Miller HG, Bopp CA, Blake PA. 1982. Campylobacter enteritis — a large outbreak traced to commercial raw milk. West J Med 137:365-9
163. Terhune C, Sazi E, Kalishman N, Bobst J, Bonnlander B, Googins JA, Williams P. 1981. Raw-milk-associated illness — Oregon, California. Morbid Mortal Weekly Rep 30:90-2
164. Tettmar RE, Thornton EJ. 1981. An outbreak of Campylobacter enteritis affecting an operational Royal Air Force unit. Public Health 95:69-73
165. Tompkins BJ, Wirsing E, Devlin V, Kamhi L, Temple B, Weening K, Cavallo S, Allen L, Brinig P, Goode B, Fitzgerald C, Heiman K, Stroika S, Mahon B. 2013. Multistate outbreak of Campylobacter jejuni infections associated with undercooked chicken livers — Northeastern United States, 2012. Morbid Mortal Weekly Rep 62:874-6
166. van Dijk WC, van der Straaten PJC. 1988. An outbreak of Campylobacter jejuni infection in a neonatal intensive care unit. J Hosp Infect 11:91-2
167. Van Houten C, Baker L, Weidenbach K, Bryan K, Murphy T, Mainzer H, Sarisky J, Hill V, Fitzgerald C, Luce R. 2007. Brief report: gastroenteritis among attendees at a summer camp — Wyoming, June–July 2006. Morbid Mortal Weekly Rep 56:368-70
168. Van Houten C, Musgrave K, Weidenbach K, Murphy T, Manley W, Geissler A, Pride KR. 2011. Campylobacter jejuni infections associated with sheep castration — Wyoming, 2011. Morbid Mortal Weekly Rep 60:1654

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute

169. Vogt RL, Sours HE, Barrett T, Feldman RA, Dickinson RJ, Witherell L. 1982. Campylobacter enteritis associated with contaminated water. Ann Intern Med 96:292-6
170. Weltman A, Longenberger AH, Moll M, Johnson L, Martin J, Beaudoin A. 2013. Recurrent outbreak of Campylobacter jejuni infections associated with a raw milk dairy — Pennsylvania, April–May 2013. Morbid Mortal Weekly Rep 62:702
171. Wensley A, Coole L. 2013. Cohort study of a dual-pathogen point source outbreak associated with the consumption of chicken liver pâté, UK, October 2009. J Public Health 35:585-9
172. Winquist AG, Roome A, Mshar R, Fiorentino T, Mshar P, Hadler J. 2001. Outbreak of campylobacteriosis at a senior center. J Am Geriatric Soc 49:304-7
173. Wright EP, Tillett HE, Hague JT, Clegg FG, Darnell R, Culshaw JA, Sorrell JA. 1983. Milk-borne Campylobacter enteritis in a rural area. J Hyg 91:227-33
174. Yanagisawa S. 1980. Large outbreak of Campylobacter enteritis among school children. Lancet 2:153
175. Yoda K, Uchimura M. 2006. An outbreak of Campylobacter jejuni food poisoning caused by secondary contamination in cooking practice at a high school. Jap J Infect Dis 59:408-9
176. Yoder JS, Hlavsa MC, Craun GF, Hill V, Roberts V, Yu PA, Hicks LA, Alexander NT, Calderon RL, Roy SL, Beach MJ. 2008. Surveillance for waterborne disease and outbreaks associated with recreational water use and other aquatic facility-associated health events — United States, 2005–2006. Morbid Mortal Weekly Rep 57:1-38
177. Yoder JS, Roberts V, Craun GF, Hill V, Hicks LA, Alexander NT, Radke V, Calderon RL, Hlavsa MC, Beach MJ, Roy SL. 2008. Surveillance for waterborne disease and outbreaks associated with drinking water and water not intended for drinking — United States, 2005–2006. Morbid Mortal Weekly Rep 57:39-68
178. Young NJ, Day J, Montsho-Hammond F, Verlander NQ, Irish C, Pankhania B, Oliver I. 2014. Campylobacter infection associated with consumption of duck liver pâté: a retrospective cohort study in the setting of near universal exposure. Epidemiol Infect 142:1269-76
179. Yu JH, Kim NY, Cho NG, Kim JH, Kang YA, Lee HG. 2010. Epidemiology of Campylobacter jejuni outbreak in a middle school in Incheon, Korea. J Korean Med Science 25:1595-600
180. Zeigler M, Claar C, Rice D, Davis J, Frazier T, Turner A, Kelley C, Capps J, Kent A, Hubbard V, Ritenour C, Tuscano C, Qiu-Shultz Z, Leaumont CF. 2014. Outbreak of campylobacteriosis associated with a long-distance obstacle adventure race — Nevada, October 2012. Morbid Mortal Weekly Rep 63:375-378.
181.Braeye T, De Schrijver K, Wollants E, van Ranst M, Verhaegen J. 2014. A large community outbreak of gastroenteritis associated with consumption of drinking water contaminated by river water, Belgium, 2010. Epidemiol Infect July 25:1-9
182. Centers for Disease Control and Prevention. 1997. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1997_linelist.pdf. AccessedSeptember, 2014.
183. Centers for Disease Control and Prevention. 1996. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1996_linelist.pdf. AccessedSeptember, 2014.
184. Centers for Disease Control and Prevention. 1995. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1995_linelist.pdf. AccessedSeptember, 2014.
185. Centers for Disease Control and Prevention. 1994. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1994_linelist.pdf. AccessedSeptember, 2014.
186. Centers for Disease Control and Prevention. 1993. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1993_linelist.pdf. AccessedSeptember, 2014.
187. Centers for Disease Control and Prevention. 1992. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1992_linelist.pdf. AccessedSeptember, 2014.
188. Centers for Disease Control and Prevention. 1991. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1991_linelist.pdf. AccessedSeptember, 2014.
189. Centers for Disease Control and Prevention. 1990. Foodborne Disease Outbreak Line Listing. Available at: http://www.cdc.gov/foodsafety/pdfs/1990_linelist.pdf. AccessedSeptember, 2014.
190. Jackson N. 2014. Officials say raw milk sickened Durand high school football team. The Country Today. Available at: http://www.thecountrytoday.com/front_page/article_604019c4-6397-11e4-b60d-efb927716fc7.html. Accessed 6 Nov 2014.

Corresponding author: M. Ellin Doyle, Ph.D., medoyle@wisc.edu
Funded in part by the North American Meat Institute